POWER

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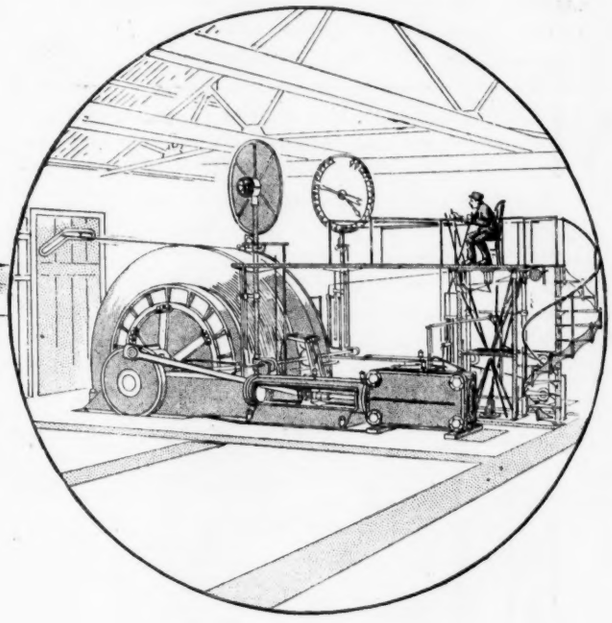
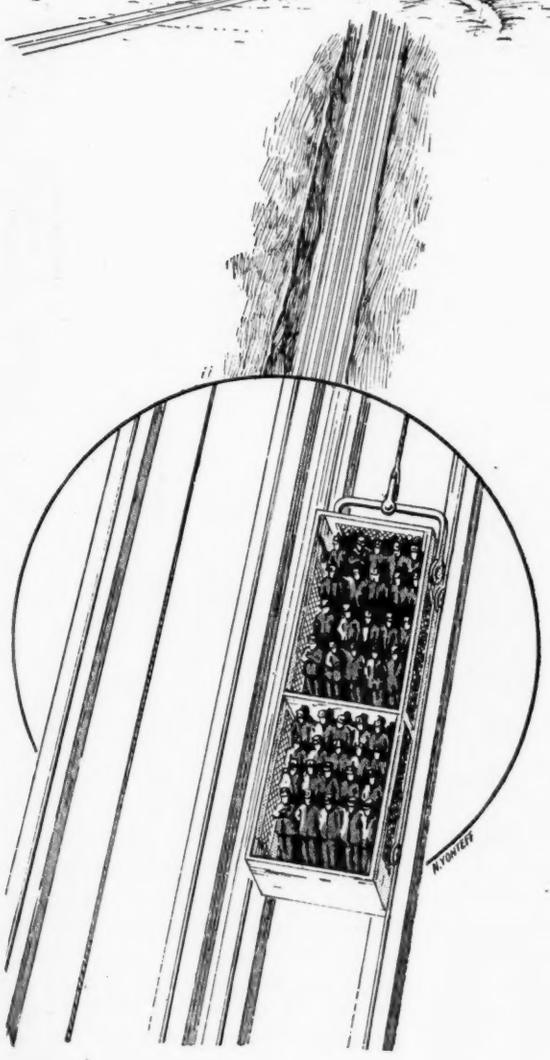




Deep-Mine Hoisting Engineers

Perched on the operating platforms, their movements dictated by the clanging of a gong, are the hoisting engineers. The ease with which they operate the massive hoisting engines of the iron and copper mines gives but slight indication of the responsibility that rests upon them in the performance of their duties. Carelessness on their part can cause a vast amount of damage, let alone the maiming and killing of the miners. If you were to step on the man skip to be lowered more than a mile below the surface of the earth, it is ten to one that there would be visions of a broken cable followed by a funeral and flowers. It is more than probable that the hoisting engineers would not be given a thought. And yet the life of every man that goes down into a mine is in their hands. They hoist hundreds of miners thousands of feet every day and think of it as merely a part of their day's work. They are cool, intelligent, and are the right-men in-the-right-place engineers.

New Armour Boiler Plant

By THOMAS WILSON

A modern installation of 4000 hp. to supplement an older plant having 12,800 hp. in boilers. The new plant, built to operate on continuous overload, has complete coal- and ash-handling facilities, duplicate provision against interruption of water supply and an unusually full complement of instruments. The boilers are of the Stirling type equipped with chain-grate stokers.

MONEY has not been spared to make the new boiler plant just completed by Armour & Co. one of the best in the City of Chicago. It is admirably laid out for convenience of operation, the equipment is good throughout, and a full complement of instruments should insure economy.

Those familiar with the packing industry will realize that enormous quantities of steam are required. At the Armour plant some of this steam goes to the refrigerating plant, one of the largest in the country, containing seven ammonia compressors with an aggregate capacity of 3500 tons of refrigeration. In the same plant there are engine-driven generating units rated for a total of 4500 kw. and four air compressors that will deliver 13,000 cu.ft. of air per minute. There is also much pumping of brine and water. Of the latter alone the average daily requirement is about 8,000,000 gal. All available exhaust steam is utilized for heating, drying, evaporating and for certain other processes in the manufacturing plant. For cooking, great quantities of live steam amounting to about 75 per cent. of the total steam generated must be reduced from boiler pressure to meet the needs of the service, pressures of 40 lb. and upward being used for this work.

No miniature plant would serve the requirements cited. Thirty-two vertical boilers aggregating 12,800 hp. had been installed, but with a growing business and the demand for steam increasing, it was necessary to supplement the output. No space was available in the older plant, so a new boiler house was erected on the nearest site. The new boilers will operate in conjunction with the older installation. A section of one of the boiler settings is shown in Fig. 3. The new equipment, consisting of eight 502-hp. Stirling boilers, will all be operated at 160 to 180 per cent. of rating. With this additional 7000 hp. it will not be necessary to force the older plant. The boilers can be operated at their most efficient load, and generally better boiler-room conditions may be obtained.

The illustrations show a brick and steel building measuring in plan 80 x 84 ft. and 83 ft. in height to the monitor roof. The boilers were arranged four on a side and set in batteries of two, with a central firing aisle topped by the coal bunker. In accordance with good practice the settings are high, the center of the mud drum being 6 ft. above the floor and the steam drum 25 ft. 10½ in. The bridge-wall is also high, being built up about 20 in. above the pressure waterbacks. Flat ignition and combustion arches are employed, the latter being a double arch of the inclosed ventilated type, with openings through the side walls for cooling. Between the tubes and the combustion arch the minimum space is 18

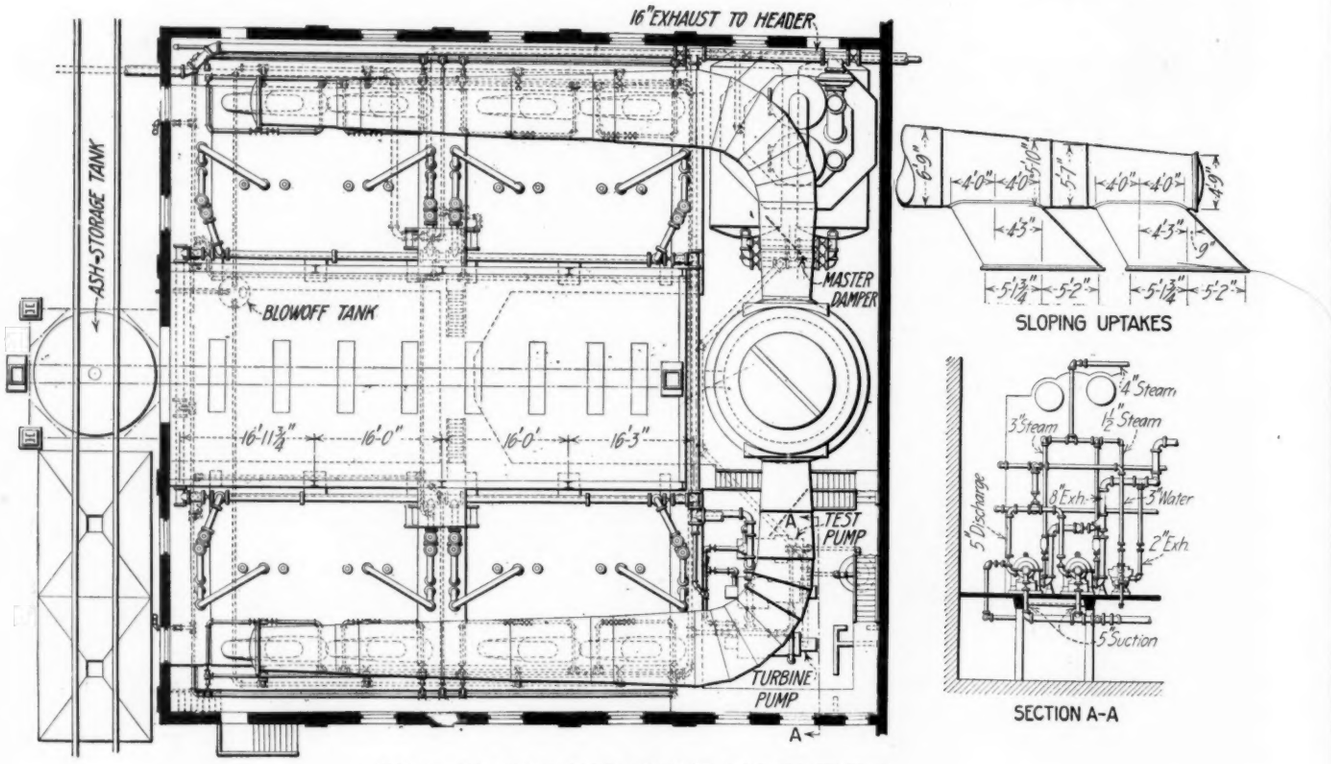


FIG. 1. PLAN OF NEW ARMOUR BOILER HOUSE

in. The B. & W. superheater in the second pass is designed for 50 deg. of superheat, the operating pressure being 150 lb. gage.

Each boiler, with 5016 sq.ft. of heating surface, is served by a Green chain grate having an effective area of 100 sq.ft., giving an even ratio of grate to heating surface of 1 to 50. From the plan view, Fig. 1, it is seen that the stack centers on the firing aisle at one end of the building. A long-radius turn in each run of breeching permits entrance to the stack on opposing sides, interference of the gases being prevented by a vertical division wall in the stack at this point. The stack was built of Custodis radial brick to a height of 265 ft. above the foundation, or 250 ft. above the grates. The inside diameter at the top is 12 ft., giving an area of 113 sq.ft. as compared to a combined breeching area of 142 sq.ft., a reduction of approximately 20 per cent.

Over the boilers the breeching is of circular section, changing to an oval at the stack with 71 sq.ft. of area. It is made of ¼-in. metal and tapers so that each square foot of section will serve 5.64 sq.ft. of connected grate area. Summarizing, for each 1000 sq.ft. of boiler-heating surface there are 20 sq.ft. of effective grate area, 3.55 sq.ft. of breeching and 2.83 sq.ft. of stack, proportions that conform with good practice and with the requirements of the Chicago smoke department.

A feature is the provision of uptakes sloping in the direction of the flow of the gases. Although this is expensive construction, it tends to reduce the drop in draft by eliminating a right-angle turn at this point. At the base of the stack a draft of 1½ in. is expected to result in a comparatively strong draft over the fire. This will be regulated by the individual damper at each boiler and a master damper in the breeching, near the stack, controlled by a McDonough regulator.

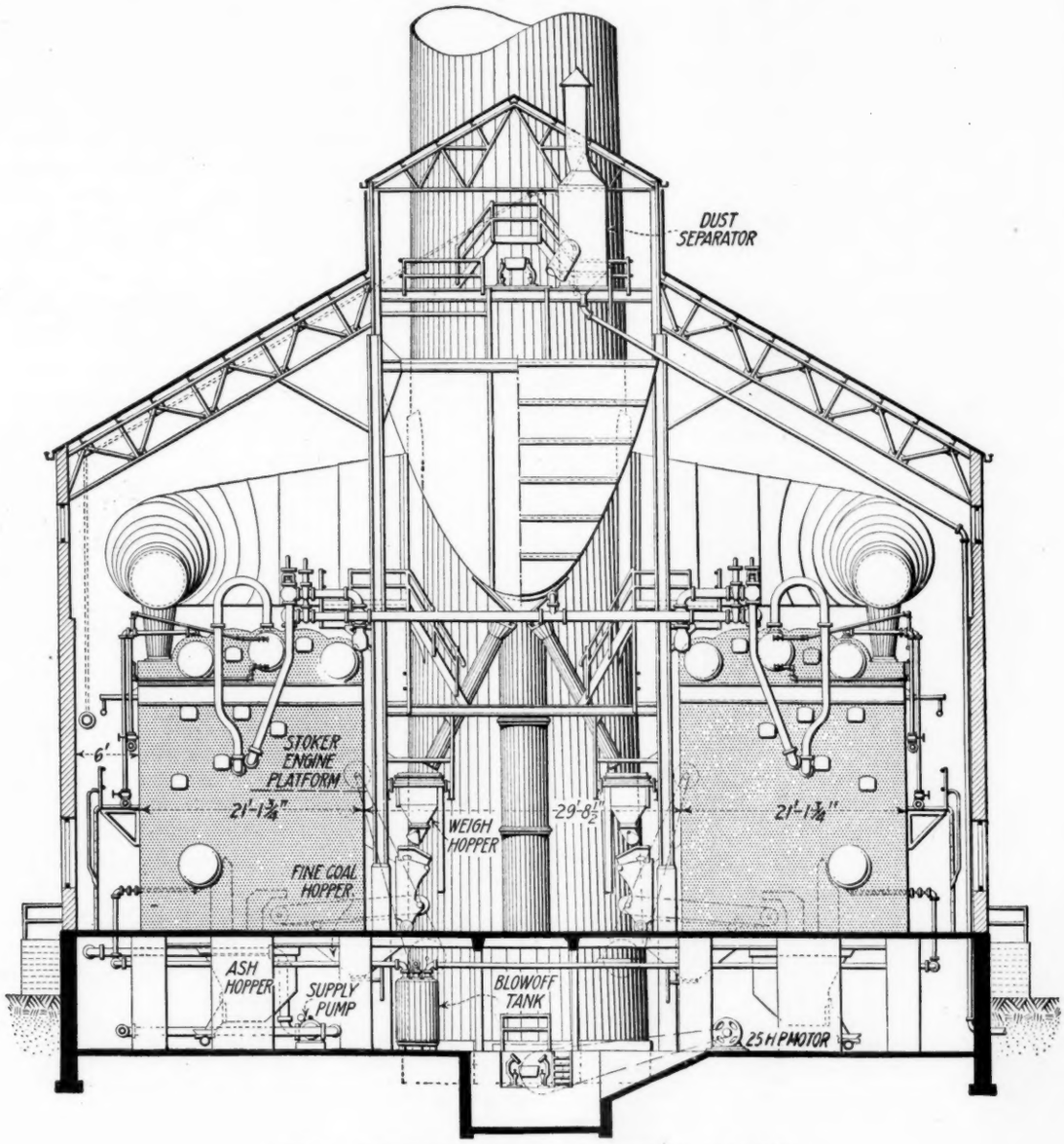


FIG. 2. SECTIONAL ELEVATION THROUGH PLANT

Four of the boilers have Diamond soot blowers and the other half Vulcan blowers. In the blowoff connections are Homestead cocks and Johnstone gates. A venturi meter in the pump-discharge line will measure the water supply to the boilers, and a Kennicott water weigher

has been provided for testing purposes. In the way of instruments each boiler will have an illuminated pressure gage, a G. E. steam-flow meter, a CO_2 recorder furnished by the Combustion Appliance Co., an Ellison differential gage to measure the draft over the fire or the drop through the setting, and a Foxboro recording pyrometer to give gas temperatures in the uptake. It is the intention to mount these various instruments on panels near the boiler fronts, so that they will be in plain view of the fireman to help him maintain the high economy expected from the plant. As is the practice in the other plants of the company, the records will be filed with the motive-power department, where they are carefully analyzed and compared with a view to maintaining or improving operating conditions and ascertaining the cost of making steam. Fig. 2 is a sectional elevation.

Coal-Handling Facilities

One of the features of the plant is its complete coal-handling system. The fuel comes in over a spur track running along the side of the boiler house. It is provided with a double-track hopper of the same length as a coal car, and beyond the hopper there will be room for three additional cars. Thus four cars will be set at one time, the first car over the hopper to be unloaded. As the track has a slight incline, the car can be uncoupled and allowed to free itself from the others by gravity. The second car is then set and unloaded, and so on until the four cars have been emptied, gravity helping the movement of the cars in each case. It is estimated that 300 tons of Illinois screenings will be burned in 24 hours, so that approximately six cars must be unloaded per day to keep up with the requirements.

The hoppers discharge upon a 30-in. steel apron conveyor with a run of 38 ft. to a double-roll crusher. In order that the two track hoppers may not discharge upon the apron conveyor at the same time, the rear hopper is provided with a swinging chute that is raised while the front hopper is discharging. As soon as it is empty, the swinging chute is lowered and the rear hopper freed of coal. The conveyor is driven by a 5-hp. geared motor at a speed of 4.5 ft. per min. It delivers to a double-roll 30 x 36-in. Link-Belt crusher of the spring-release type designed to crush 50 tons of coal per hour. If no crushing is necessary, the rolls may be separated to permit the coal to pass through to a continuous bucket conveyor immediately below. The driving power is supplied by a 25-hp. belted motor. Convenient means have been provided to remove the crusher in case of accident. It may be pulled out on inclined beams, hoisted to the boiler-room floor for repairs and returned to its original position in a comparatively short space of time, the coal in the meantime dropping directly into the bucket conveyor.

The Peck carrier has 24 x 24-in. buckets, its capacity at a speed of 40 ft. per min. being 50 tons per hour. A silent-chain drive is the connection to a 10-hp. motor located on the upper run of the conveyor over the bunkers. In the connections for this motor, as well as the others mentioned, provision has been made so that they may be stopped by push-buttons from the basement, the first floor or above the bunkers. The starters for all the motors are on the main floor. On the lower run the carrier passes under spouts from the fine-coal hoppers underneath the stokers. On the upper run it passes directly over the ash tank and the coal bunker, which is of catenary type built to hold 750 tons. A traveling discharger dumps the coal at any desired point.

From the bunker coal is chuted through undercut gates to either one of two Phillips Lang traveling weigh hoppers electrically propelled along the boiler fronts, the coal being discharged from the weighing device into any one of the four stoker hoppers on the same side of the firing aisle. Extension chutes are provided so that the fuel may be fed directly to the stoker if desired.

Ashes are handled by a steam-jet conveyor system furnished by the American Steam Conveyor Corporation. Horizontal runs of 8-in. pipe under each row of boilers discharge into vertical risers leading to a 100-ton ash tank mounted directly over the coal spur and, as previously stated, under the Peck carrier, so that in case of a breakdown of the steam-jet system the carrier may handle the ashes. For this purpose a special chute on top of the ash tank, with a gate normally kept closed, has been provided. With the gate open the traveling discharger may be set to dump the ashes into the tank. The ash hoppers under the boilers are of sufficient size to hold a day's run of ashes, so that it will be necessary to empty them but once in 24 hours. Special

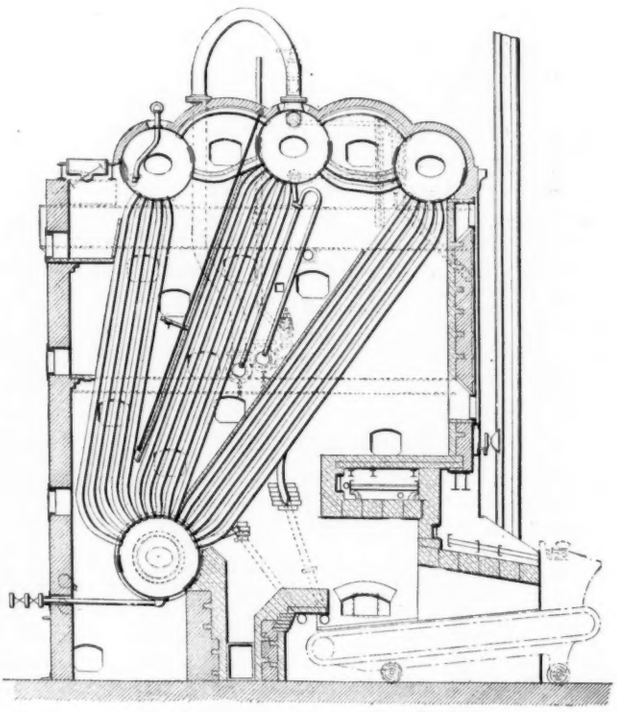


FIG. 3. SECTION OF BOILER SETTING

chutes guide the ashes directly into the receiving hoppers of the conveyor.

With city water as feed for boilers forced beyond their normal rating, it was considered desirable to install a William Graver hot-process softening system. Reduction of the incrusting solids to three grains or less per gallon would improve operating conditions, resulting in higher average efficiency and less frequent cleaning. The softener has duplicate open heaters, a precipitating tank and duplicate quartz filters, the duplication providing for continuous operation while one filter or heater is out for cleaning or repairs. Instead of discharging the

sludge from the precipitating tank into the sewer, it is collected in a settling basin and eventually removed.

As the open heaters are above the precipitating tank, the city water must be elevated about 40 ft. The pressure in the mains rarely being sufficient for the purpose, a booster pump was necessary. If this unit, an 8-in. De Laval turbine-driven centrifugal, should fail, recourse may be had to the feed-water system of the older plant.

After being softened and filtered, the feed water is forced into the boilers by either one of two three-stage Cameron centrifugal pumps, each having a capacity of 500 gal. per min. and driven by a Terry steam turbine. The discharge lines of these pumps unite to pass through a venturi meter to the main feed line or to an auxiliary feed line, both of which are within easy reach of a platform at the rear of each row of boilers. On the main feed line to each boiler is a Copes feed-water regulator.

The testing outfit previously mentioned consists of Kennicott weighing tanks served by a Deane plunger pump delivering to the auxiliary feed line. With this provision any one of the eight boilers may be tested while the others are fed in the usual manner from the main feed line.

As will be evident in the plan view, Fig. 1, the boilers are served by a rectangular header system with tees at the corners to provide for four main steam connections. Ample provision has been made to drain these headers through traps into the suction of the boiler-feed pumps, and they are valved so that either side may be cut out if desired. All supply lines leading to the manufacturing plant are overhead and heavily covered to reduce radiation losses. The piping is extra-heavy, and Crane valves are generally employed, an exception being the Golden Anderson triple-action nonreturn valves over the boilers.

Tom Hunter, Hoisting Engineer

BY WARREN O. ROGERS

Hunter is again encountered on a visit to the iron mines of Michigan. He gives a few facts regarding the iron-ore deposits in that district and tells how they are located and something as to how the ore is mined.

"ISHPEMING, Mich., am de nex' station 'Cap,' and we'll be dare in half an hour, right on time." I heard these words pronounced by the sleeping-car porter, as I was aroused from a sound sleep by the aid of several well-directed digs in my ribs. Kicking into my clothing as quickly as possible, I found that the porter had not allowed any too much time. At the station several other unfortunates and I collected our bags from the pile where the porter had left them. Then we started for the hotel, in the sharp, early-morning air.

Breakfast was in order. As I entered the dining room, I was assigned to a table by the ever present dining-room goddess found in country hotels. Upon looking over my fellow guests, to see how many there were whom I did not know, I discovered to my amazement my old friend, Tom Hunter.

"Hunter! By all the big and little fishes, what brings you up into this part of the woods?" I exclaimed, rushing to his side of the table and grasping his hand with genuine pleasure. "Don't you ever get away from the mining country?"

"Not for long," responded Hunter, with a hearty handshake. "I'm on a somewhat belated vacation and came up here to get some fresh air. I expect to stay about a month and look around a little on the side to see if I can find anything new in the mining line.

"This is a great iron and copper country; and if you expect to stay here for any length of time, I think that I can show you some mining stunts that will make those we found in the coal mines of Pennsylvania and the iron mines of Alabama look like 30 cents."

While Hunter was talking, I had ordered some country sausage (made in Chicago) and fresh boiled eggs (right off the nest, by the taste). I told Hunter that I would be in that part of the country about four weeks and that there was no reason why we couldn't inspect the various mining propositions together.

"That will be great!" exclaimed Hunter. "I was wondering what I would do with myself here all alone. You know, of course, that the most prominent iron-ore producing district in the world comprises five ranges all located near the shores of Lake Superior, all in three states—Michigan, Minnesota and Wisconsin. If I am not mistaken, the first regular ore shipments from Michigan were in 1856—that's 61 years ago—on the Marquette Range, where we are at present. Sometime about 1872 iron was found on the Menominee Range, and then on the Gogebic Range in 1884. In the State of Minnesota iron ore is obtained from the Vermilion and the Mesabi Ranges. The latter was opened in 1892 and is in the first rank as a producer. In fact, during late years the Mesabi Range mines have produced about one-half of the total output for the Lake Superior region."

"They must produce some iron ore if that is the case," I said, as I fished through my pockets for a couple of cigars, but found none.

"Yes; why, from the Marquette Range the shipment of iron ore for 1915 was 4,105,378 tons. In fact, this range was the prominent producer and for years occupied either second or third position. I believe the total output for the Lake Superior region in 1915 was 47,074,564 tons, and the Mesabi mines shipped 29,756,689 tons of that. It is estimated that the total iron ore produced in 1916 will be around 70,000,000 tons; if so, it will be the record.

"You won't find that the above-ground practice in iron mining differs much from that of mining coal. Of course, there is no breaker, but there are boiler and engine rooms. The boilers are of the ordinary water-tube and return-tubular types, generally hand fired. Adjoining the boiler room is the hoisting engine, and the same room usually contains an air compressor for supplying air to the air drills in the mines. The air pressure delivered to the mine is generally about 80 lb."

We had by this time finished breakfast, and Hunter suggested that we get the necessary permission to visit

some of the more important shafts of the Cleveland Cliff mines, of which there were a number in the vicinity. We started out and were soon on our way to one near-by (Fig. 1).

We found that the power plant was housed in a brick building with one chimney serving the boilers, and not a collection of iron stacks as so frequently found at coal-mine plants. The hoisting engines were much larger in general than those found at coal mines, and the compressors were, as a rule, arranged with cross-compound air and steam cylinders (Fig. 2), and ran at about 40 r.p.m.

"Iron mines differ in depth," said Hunter, as we neared the shaft of the Lake mine. "Some are only about 300 ft. deep, and others go down over 2000 ft. In the Mesabi Range much of the iron ore lies near the surface and is mined by the use of steam shovels having a capacity of about five tons per shovel. Some iron ore runs 60 per cent., but the supply is small. There is, however, a large amount of 50 per cent. ore and an almost inexhaustible supply of 40 per cent. ore, so you need not have fear of an iron-ore famine."

At the Lake mine we were told of the work going on at the New Holmes mine, which will be the last word in iron mining in the Michigan district when finished. The headframe, Fig. 3, shows the general construction. It contains 290 tons of steel and will accommodate two ore skips and a man cage. The shaft is 1250 ft. deep, and the hoisting apparatus will be electrically operated.

"How did they discover the presence of iron in the first place? Does it outcrop the same as coal?" I asked Hunter, as we started for another mine to see some of the hoisting machinery.

"Well," replied Hunter, "there are a lot of legends handed down from the Indians who roamed around this section of the country years ago regarding what they called 'hard rock,' and the white settlers knew about it; but it was not until 1844 that some Government surveyors located the first iron ore in Michigan. They found in carrying out their work that there was a variation in the magnetic needle of their instruments, and this led to the final discovery of iron ore near Teal Lake; but it didn't amount to anything at that time. As I remember reading, it was three years later when the first forge was started somewhere on the Carp River and produced at its greatest capacity three tons per day. The Marquette Range did not amount to much until about 1856.

"There are approximately 3800 sq.mi. of iron-bearing districts in the Lake Superior region, and they lie at an average elevation of 1500 ft. above sea level. In the Marquette district, where we are now, the ores are mostly soft, red hematites, and the iron formations extend in general from east to west. The greater proportion of the ore deposits that come to the surface are located on the middle or upper parts of the slopes. It was the outcrop that led to the discovery of iron ore in this district."

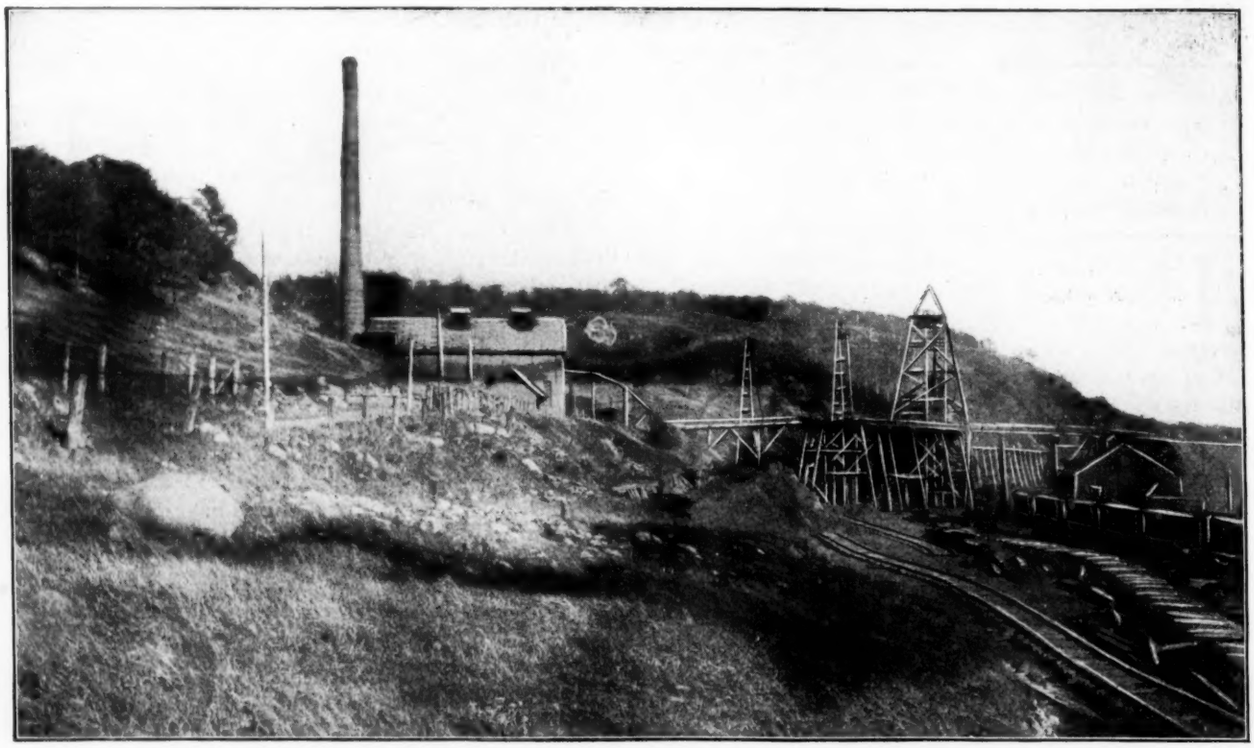


FIG. 1. TYPICAL VIEW OF AN IRON MINE, SHOWING THE ABOVE-GROUND LAYOUT, NEAR ISHPEMING, MICH.

"What gets me is how they know where the iron ore is where there is no outcrop."

"Well, it is no cinch," replied Hunter. "The exploration for iron ore is just as much an engineering job as the mining of the ore after it is located. A geologist must not only be familiar with the characteristics of the rock formation surrounding ore beds, but he must be familiar with the particular section of country where he is to work; and the less haphazard methods and guesswork the better. The earlier methods of exploring for iron ore were by means of trenches, test pits and shafts. When the deeper works were met with,

diamond and churn drills were used. I believe the first diamond drilling was done about 1877 near this city (Ishpeming). As the ore is found at considerable

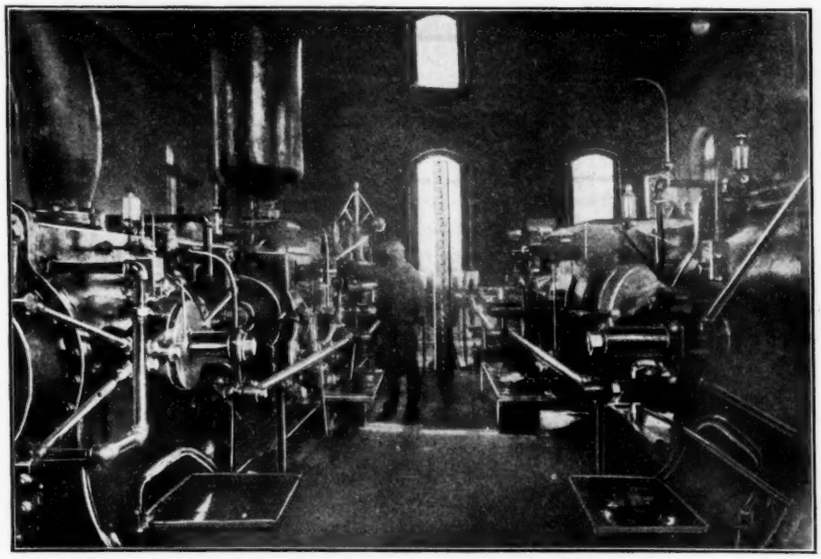


FIG. 2. VIEW BETWEEN THE CYLINDERS OF A CROSS-COMPOUND AIR COMPRESSOR

depth, both vertical and angle holes are drilled, averaging about 300 ft. deep.

"Locating orebodies has, like most other things, been the result of development; and present-day methods are the result of over 25 years' experience, during which time the matter has been studied from every engineering standpoint."

"What do they use a churn and a diamond drill for?"

"It's this way. When drilling through the surface drift, and in soft formations as well, a churn drill is used. The cutting is done by percussion instead of by a rotary movement, as is the case with a diamond drill. The cutting end is made like a chisel-shaped bit, with perforations near the cutting edge. The upper end of the drill is threaded and screwed to a line of drill rods, consisting of extra-heavy pipe. A flexible pipe connects the upper end of the rods to a pump, and water is forced down through the rods and out through the perforations in the bit. It comes up between the rod and the casing pipe and carries the cutting to the surface."

"Well, how does the churn drill get its motion?" I asked, because Hunter appeared to have finished with the subject.

"A rope is passed through the upper end of the line of rods, then over a sheave, in a tripod frame, then down, and is wound several times around the drum of the churn-drill engine, the end being left loose. The drill runner alternately tightens and slackens this rope as the drum revolves. The rising and dropping of the bit causes the rod to turn slightly at each stroke."

"Well, what about diamond drilling; how do they do that?"

"Diamond drilling consists of screwing a line of hollow rods together. They are about 10 ft. long. The whole is rotated by an engine through a shaft and gearing. The bit is at the bottom of the line of rods and is an annular piece of steel in which are set what are known as black diamonds. The bit is fed by a screw or by a piston working in a hydraulic cylinder. The bit cuts a hole in the rock as it advances, usually $1\frac{9}{16}$ in., and has a $\frac{15}{16}$-in. core. Water is forced down through the rods and carries the cuttings to the surface. The core is forced into the lower rod and is brought to the surface when the rod is pulled from the hole. Generally, a sample is taken at 5-ft. intervals. "There have been lots of cases where the orebody was missed in drilling, just because not enough attention was given to the examination of the drill core. For instance, in the Crystal Falls district I remember they stopped drilling in a fine-grained gray dike because the core from the dike was mistaken for the foot-wall slate. Later, another company employed an experienced geologist, who examined the core samples from the dike and decided that they were not slate. A hole was drilled through the dike, and an ore bed 100 ft. thick was found. Another case was at the Negaunee basin, where we are headed for now. A vertical drill hole was sunk 800 ft. and was then abandoned, because it had cost about $4000 and because a slaty phase of the ore formation was cut at that depth that looked similar to the foot-wall material. If the drilling had been carried

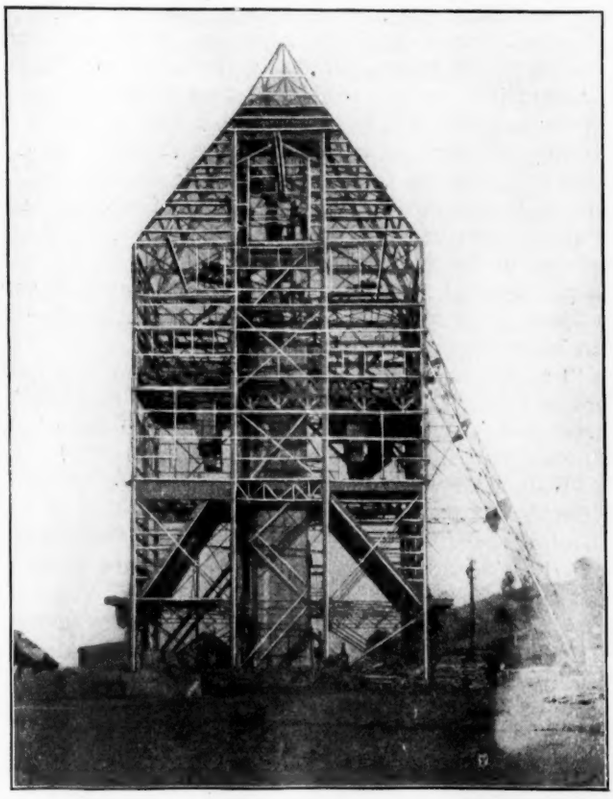


FIG. 3. HEADFRAME OF THE NEW HOLMES MINE

down another 100 ft., a good-sized orebody would have been found concentrated between a fold of foot-wall slate. The great ore beds of this basin as a consequence remained unknown for years.

"The story goes that George Maas had in his possession an old sketch map of the Marquette district that had been made by a German. Printed over the present location of the Maas mine were the words, 'Here is a good place to look for iron ore.' Mining men laughed at the idea of there being ore under a flat field where Maas began drilling, but he located an orebody of 10,000,000 tons.

"In underground mining the caving system is used, which allows the surface to settle as the ore beneath is taken out. At the mine we just left, you saw that the outside development consisted of a shaft. At the bottom are a shaft station and a pumproom. Then there are a main haulage level and rises, drifts and crosscuts on the sublevels, and as much of this as is possible is done in the orebody. The rises are run up to barren

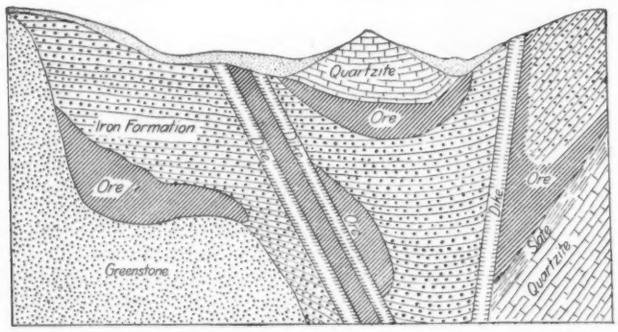


FIG. 4. REPRESENTING A VERTICAL SECTION THROUGH MARQUETTE ORE DEPOSITS

or caved ground, and drifts are run in the ore from the top of the raises, parallel to the main drift below. These drifts are extended until they reach the limits of the orebody or to the ground that has already been caved. At such points crosscuts are driven from the ends of the drifts to the limits of the orebody, and a mat of timber is laid on the floor. The timbering supporting the crosscuts is then blasted out; and the overburden, or top surface, is allowed to cave, the process being repeated until the pillars are all removed and work on a new section is begun. This is continued until the entire deposit has been removed."

"I gather from what you have just told me that iron ore as mined in this part of Michigan is found in a great pocket and not in seams, as is coal," I remarked, as we stumbled down the hill from the mine.

"Wait a minute, and I will make a sketch," replied Hunter. He pulled out a notebook and made a sketch about as shown in Fig. 4. "This," said he, "represents a vertical section through the Marquette ore deposits and the rock formation surrounding them. You will see that some of the ore deposits are near the surface and that others are at a deeper level, the maximum depth being still unknown. The greatest depth that I know of is 2000 ft. in the Champion Area, and it is known to extend farther; how much, I don't know.

"The ore is generally mined by the caving system, where the deposits have a comparatively large horizontal area, and consists of top slicing and subdrifting. The former is used with ores that are more or less mixed in grade and that are easy to cave. The subdrift system is used with harder formations and ores of uniform grade, as it is difficult to separate the different grades with this system.

"A shaft is sunk some distance from the orebody deposits, and haulageways are constructed in the solid rock to the ore. Then the ore is mined as I have already described."

We had by this time returned to the town, and taking a street car, we started for the Negaunee mine.

Single Unit Turbo-Pump

An interesting development in the direction of compactness and simplicity is shown by Fig. 1 of a 3000 boiler horsepower two-stage centrifugal boiler feeder combined in one casing and on one shaft with a velocity-stage steam turbine. This unit, which has been developed by the De Laval Steam Turbine Co., Trenton, N. J., weighs only about one-tenth as much as a duplex reciprocating pump of the same delivery and occupies only about one-eighth as much floor space and one-fifteenth as much cubical space.

The pump end contains two single-suction impellers. Two impellers are used for pressures up to 200 lb. per sq.in. and three for higher pressures. Single-stage boiler-feed pumps have been built, but two or three stages are preferable because of the much longer life of the impellers at slower speeds. Each impeller discharges into a volute chamber by means of which the velocity in the water as it leaves the impeller is converted into pressure before the water is led to the eye of the succeeding impeller.

The suction end of the pump is adjacent to the turbine, and the shaft packing between the turbine and

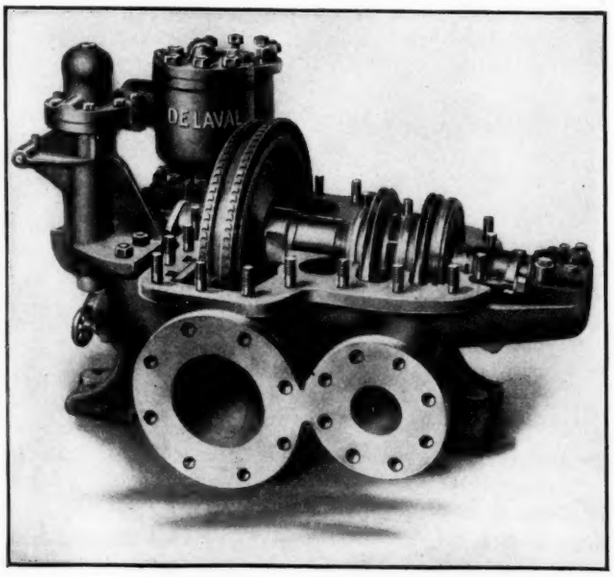


FIG. 1. DE LAVAL COMBINED TURBINE-DRIVEN CENTRIFUGAL BOILER FEEDER

pump chambers is hence subjected to the turbine exhaust pressure on one side and the suction pressure on the other. A simple packing is therefore sufficient, and in any case a small leakage of steam in one direction or of water in the other does no harm. As the leakage space adjacent to the balancing chamber at the discharge end of the pump is connected back to the pump suction, the packing about the shaft is subjected only to suction pressure. Aside from the intermediate

packing already mentioned, there is only one steam packing that is subjected to exhaust pressure.

The steam end of the unit consists of a velocity-staged turbine with either two or three rows of moving buckets, according to the steam economy desired. The nozzles can be proportioned for either high-pressure steam exhausting to the feed-water heater or to the condenser, or for low-pressure steam exhausting to the condenser, or the unit can be made interchangeable, thus permitting of a great degree of flexibility in plant design.

The unit is in some instances fitted with a speed governor mounted upon the end of the shaft, and when running at constant speed, the head varies with the delivery, as shown by the curved characteristic in the chart, Fig. 2. As will be seen, the rise in pressure at reduced capacity is not excessive. Ordinarily, however, a pump governor controlled by the pressure at some point in the feed line near the boilers is employed to control the speed, giving a practically uniform pressure at all deliveries, as shown by the lower and straight

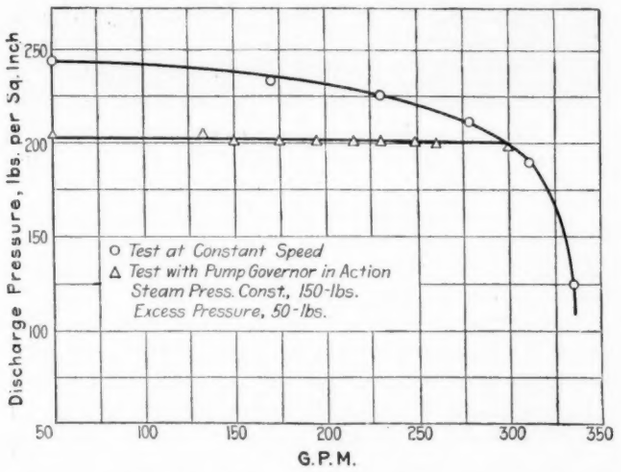


FIG. 2. HEAD DELIVERY CHARACTERISTICS OF BOILER FEEDER UNDER CONTROL OF THE SPEED AND THE PRESSURE GOVERNORS

line in the chart. In case of failure of the pressure governor to operate, the control of the unit is automatically taken over by the speed governor. However, to provide against any possibility of racing, an emergency governor is also employed.

Unaflow Engine Economy

BY A. D. SKINNER

The writer's attention has been called to several communications to the mechanical press in which complaint was made regarding the lack of information concerning the economy of uniflow engines. Over four hundred tests have been made on about thirty Universal Unaflow engines, some of the results of which are not only American records for economy under the conditions obtaining, but will also be acknowledged, I believe, to be world's records as well.

This engine has a small clearance when operating either noncondensing or condensing. Extremely high steam pressures and superheat are not essential to the obtaining of low steam rates. The greater the thermal efficiency of any steam-engine cylinder, the less will be the apparent saving due to superheat, as superheat tends to correct the losses occasioned by improper cylinder design. With one exception, therefore, the economies recorded here were obtained under saturated-steam conditions. All the tests mentioned were made by well-

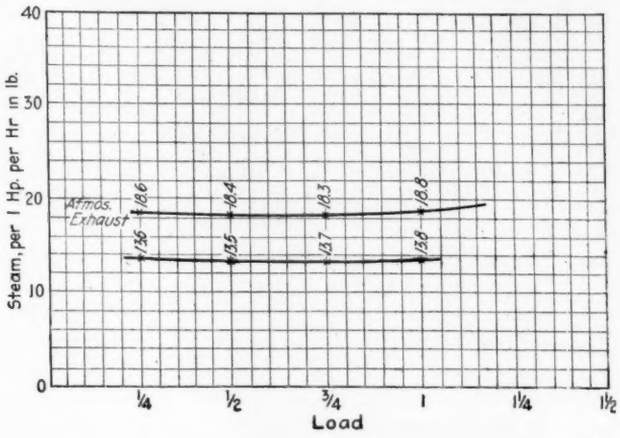


FIG. 1. CONDENSED AND NONCONDENSING TESTS OF A 21 x 22-IN. UNAFLOW ENGINE; STEAM 140 LB.

known mechanical engineers employed by the purchasers.

The purchasers of twelve Universal Unaflow engines decided to have one of the last engines shipped, a 21 x 22-in., tested before it left the shop, and they sent their mechanical engineer to conduct these trials, the results of which are graphically shown in Fig. 1. These tests were all made on the same day, saturated steam being supplied to the cylinder. The condensing and noncondensing tests were made without shutting down the engine and without making any changes whatever, the engine automatically adjusting itself to the change of exhaust-pressure conditions. Both the noncondensing and condensing curves are lower than anything we have yet seen recorded on any other make of engine operating under the conditions named.

If two engines had been built, one designed expressly for noncondensing service and the other for condensing

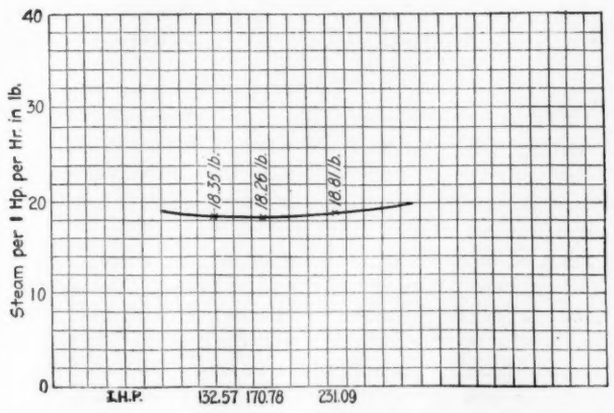


FIG. 2. TEST OF 19 x 20-IN. ENGINE; STEAM PRESSURE 146.5 LB., BACK PRESSURE 1.14 LB., 204 R.P.M.

operation, and these two engines when tested under the conditions for which they were designed had shown these respective economies, each would have been credited with a world's record; but the figures shown are the more remarkable when it is remembered that one

engine, tested under both conditions and without any change whatever being made, accomplished these extraordinary results.

Attention is also called to the flatness of each curve, the steam rate per indicated horsepower-hour at one-fourth load, both condensing and noncondensing, being no higher than at full load.

These results might be considered abnormal if they had never been duplicated by another engine of this type; but six months later another purchaser of two smaller engines instructed his mechanical engineer to conduct noncondensing tests under the same conditions of operation, the results of which tests are given in Fig. 2. It will be noticed that this engine produced econo-

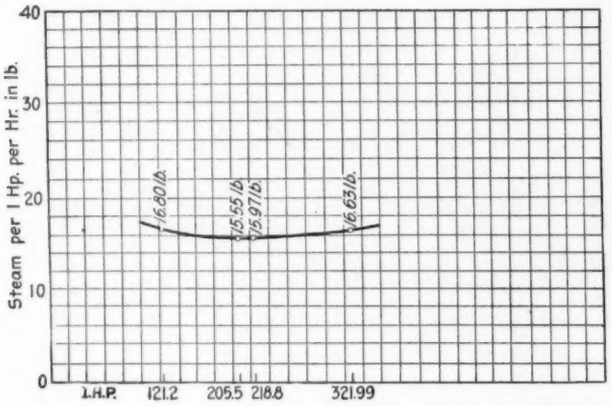


FIG. 3. TEST OF A 21 x 22-IN. ENGINE; STEAM PRESSURE 149.1 LB., SUPERHEAT 102.5 DEG. F.

mies that were identically the same as those of the larger engine which had been previously tested.

These economies have again been duplicated at a recent factory acceptance test.

Fig. 3 shows the results of tests made on a 21 x 22-in. engine with steam superheated 102.5 deg. F.

It should be borne in mind that none of the engines was especially prepared for these trials; and one of the engines was tested without the builders' having an opportunity to make a preliminary trial run.

Combination Pumps for Economizer Service*

Under ordinary conditions an economizer is subjected to a higher pressure than that carried on the boiler. With the increase in boiler pressures an increase in pressure on the economizer also obtains unless a method of overcoming it is adopted.

Such a method has been worked out whereby, instead of using one pump and subjecting the economizer to slightly higher than boiler pressure, two pumps are used (Fig. 1), the first receiving water from the heater or other source and pumping at a comparatively low pressure through the economizer, and the second receiving the water under pressure from the economizer and pumping to the boiler. In the particular case in question, the unit is guaranteed to operate as follows:

When operating with 160 lb. initial steam pressure, this unit will deliver 300 gal. of water per min. against a total head of 195 lb. The first 4 in. two-stage pump will pump directly to the economizers at a pressure of 110 lb., and the second 4-in. two-stage pump will take the water from the economizers at about 85 lb. and deliver it to the boilers at a pressure of at least 195 pounds.

When operating with 200 lb. steam pressure, the unit will deliver 300 gal. of water per min. against

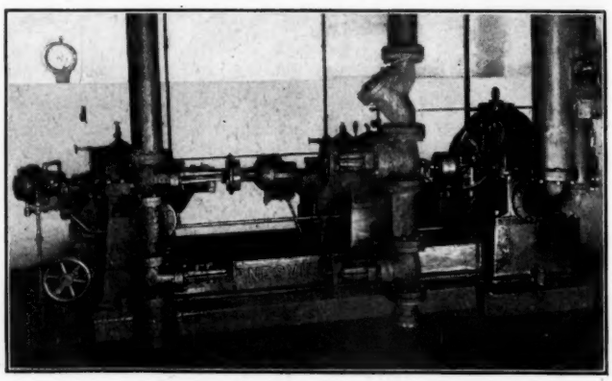


FIG. 1. COMBINATION OF TWO PUMPS AND TURBINE FOR ECONOMIZER SERVICE

a total net head of 225 lb. The first pump would pump directly to the economizers at a pressure of 125 lb., and the second pump would take the water from the economizer at about 100 lb. and deliver it to the boilers at a pressure of at least 225 lb. This unit will be designed for a maximum efficiency at 200 gal. per min. An elevation of such an installation is shown in Fig. 2.

It is evident that by the use of this combination turbine and pump, old economizers which it would not

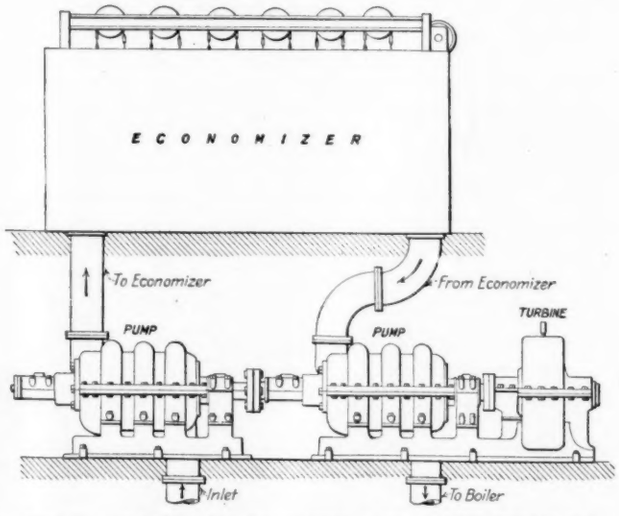


FIG. 2. ELEVATION OF PUMPS AND CONNECTION TO AN ECONOMIZER

be practical to operate at the normal pressure under ordinary service or at an excessive pressure above normal could still be used with safety owing to the reduced internal pressure.

This combination pumping outfit is manufactured by the Terry Steam Turbine Co., Hartford, Conn.

*This arrangement of pumps and prime mover was advocated by Norman G. Reinecker, page 655, Nov. 9, 1915, "Power," in a discussion pertaining to the noninstallation of economizers at the Connor Creek power plant, see page 388, Sept. 14, 1915, "Power."

Something About Humidity

By V. R. GAGE

An explanation of how humidity is measured, what it is and how it is affected by temperature and pressure.

THE instrument in the weather bureau kiosk marked "relative humidity" is supposed to show the percentage by weight of water vapor in the air, 100 per cent. being when the atmosphere can hold no more in the form of steam. The maximum weight of steam that the atmosphere is capable of holding is dependent on, and increases with an increase of, the temperature. The action of this hygrometer depends on the expansion and contraction in length of a hair or fiber as it increases or decreases in moisture content.

Another common device for measuring the relative humidity is a combination consisting of two ordinary thermometers, one having the bulb covered with a wet cloth or a wick extending into a vessel of water. In the use of this instrument the wet-bulb and the dry-bulb temperatures are taken. If they are the same, the humidity is 100 per cent., but when there is a difference it is necessary to consult tables in order to obtain the relative humidity. The engineer generally uses a "sling psychrometer," which is essentially a "wet and dry bulb" outfit so mounted that it can be rapidly revolved. The readings are the same as with the stationary type, but a table of different numerical values must be employed.

Determining Relative Humidity

The most accurate and also the most logical method of determining relative humidity is the dew-point apparatus. With this a surface is cooled until moisture is condensed from the air. The temperature at which condensation begins is the boiling point corresponding to the actual vapor pressure of the H_2O in the surrounding space. The corresponding pressure may be found from steam tables, using the dew-point temperature; the difference between the actual air temperature and the dew-point temperature gives the degree of superheat. Consulting a steam table, the weight per cubic foot of superheated steam under these conditions may be found; call this M_{act}. Then look up the weight per cubic foot of dry and saturated steam at the air temperature and call this M_{sat}. The relative humidity is $M_{act} \div M_{sat}$.

In order to understand about this matter of humidity, let us consider a few things to which perhaps we have never given much attention.

Water in a teakettle on a hot stove first boils, turns to steam and drives all the air out of the kettle. In the teakettle there is then only H_2O in the liquid and gaseous states. The steam has nearly free access to the air, so the pressure inside the kettle is not much greater than atmospheric. That means that the vapor pressure in the kettle is about 14.7 lb. per sq.in. abs., with a corresponding boiling of about 212 deg. F. So far we have considered only equilibrium between two phases, in which the vapor phase is maintained free from other gases and atmospheric pressure is maintained in the vapor space. As the steam leaves the kettle, other things happen. The vapor is separated from contact with the liquid, the total pressure in space remains the same, and the steam mixes with other gases of a lower temperature. Right here remember that steam is invisible, that what we see is the result of light reflection from the minute drops of water.

Another Example

Now let the teakettle go for a time and take up another homely matter—what happens to the clothes on wash day. They are hung out to dry, the water which they contain evaporates and goes off into the air as invisible steam. The temperature of this water never reaches 212 deg.; in fact, during the winter, the clothes freeze solid and stay below 32 deg. until they are dry. The water has changed from ice to steam and has never gone above the freezing point. A consideration of the molecules may help toward an understanding of what happens. Put a pan of water in a closed vessel, the whole to be kept at a constant temperature. For the purpose of this example it makes no difference what the pressure is; it can be a vacuum, atmospheric or several atmospheres, without appreciably altering the results. After some time has elapsed, the space inside the vessel becomes saturated with water vapor, humidity 100 per cent. H_2O; the pressure corresponds to the temperature with dry and saturated vapor.

Molecule Action

Another homely example of this type is the use of a closed vessel to keep bread from drying. Now the water consists of molecules in magnitude somewhat similar to the particles of dust of the earth's surface. For the given temperature we can know the average kinetic energy of each molecule, but actually we cannot know the velocity of a given molecule at a given time. It is like the life-insurance business. The actuaries can take a large group of men and tell how many will die at 40 years old, how many at 45, etc., but they cannot tell at what age a particular man will die. Some of the molecules have a much greater velocity for an instant and at times shoot through the surface of the liquid and get to wandering around in the space above. When enough of these molecules are in the space above so that there are just as many going back into the liquid as there are coming out, then the condition of equilibrium is established between the liquid and the vapor phases for that temperature, or in other words, we have the vapor pressure for that temperature. If the space is not inclosed, some of the molecules can escape, but nature tries to build up and maintain such equilibrium.

In the case cited the temperature was to be maintained constant. If the water vapor can escape from immediate contact with the liquid, so that the vapor pressure cannot rise to the value corresponding to the saturated condition, and if heat is not supplied, then the temperature will be lowered. The molecules with the greatest energy escape, thus lowering the average energy of the mass of molecules. This loss of energy is shown by decrease of temperature; witness, the porous earthenware jugs used to cool drinking water.

In thinking of this phenomenon, it is best to consider the atmosphere not as air, but as space. The air is made up mainly of nitrogen, oxygen and water vapor. If a cubic foot of air be taken, each gas will be found in every portion of it. That is, each one occupies the whole space. The total pressure exerted will be about 14.7 lb. per sq.in. and is the sum of the partial pressures of each one of the constituents. If any one of the components is to be placed under 14.7 lb. pressure, it will be necessary to compress it into a much smaller volume. If possible to separate the gases, each might be compressed to 14.7 lb. and then the sum of the volumes would be one cubic foot, the same as in the first place. Each gas which makes up air may be treated as though the others were not present, provided the total volume and the partial pressure are used.

Fog is caused by reducing the temperature of the air below the boiling point corresponding to the vapor pressure. In case of fog, the humidity may be said to be greater than 100 per cent., although there are some serious objections to such a usage. When there is fog, the water vapor in the air is in the form of wet steam. At 100 per cent. humidity the form is dry and saturated vapor; at less humidity, it is super-heated steam.

On a foggy day the humidity in the boiler room is generally less than 100 per cent. As the wet steam enters the room, it receives sufficient heat to evaporate the water and then to superheat the steam. More weight of vapor can be held in unit volume when the temperature (and hence vapor pressure) is higher.

The loss of heat in boiler operation due to humidity is negligible. In the first place the weight of the water vapor is relatively very small. And then the heat loss per pound of vapor is the product of the specific heat of steam and the increase of temperature from the room to the flue. The specific heat value is about 0.45 for usual humidity conditions and, $Loss = WC\ (t_f - t_a)$.

The heat loss due to the combustion of the hydrogen in the volatile matter is the sum of a portion of the heat of the liquid, all the latent heat and some heat of superheat. Represent weight of water by W, heat of liquid by q, heat of vaporization by r, temperature by t, specific heat by C; subscripts a = air, f = flue, h = vapor pressure, 212 = atmospheric pressure. The foregoing statement then is shown by

$$W[q_h + r_h + C(t_f - t_h)]$$

(If q_h is corrected to fuel temperature it may become negative) and a commonly used expression,

$$W[(212 - t_a) + r_{212} + C\ (t_f - 212)]$$

is not correct.

Inspection of a B.t.u.-entropy chart for steam shows that the total heat of one pound of dry saturated or superheated steam, for pressures less than 3 lb. per sq.in. abs., is practically a function of the temperature and independent of the pressure. The vapor pressure in the air or flue gas can hardly reach 3 lb. So the following formula[1] is true:

$$Loss = W(1090.7 + 0.455t_f - t_a)$$

A consideration of the heat loss due to combustion of hydrogen opens the question of higher and lower heating values. The former is obtained when the water thus formed is all condensed and cooled to the original temperature of the fuel, along with all the other products of combustion. A lower heating value is obtained when the water is only partly condensed or not condensed at all, or when the products of combustion are not cooled to the original temperature, or by a combination of uncondensed water and insufficient cooling. There are an infinite number of lower heating values for any fuel containing hydrogen. When the term lower heating value is used, it is necessary to inquire under what conditions it was determined. In order to make an experimental determination of the higher heating value, it is necessary to have the air and the fuel supplied for combustion at 100 per cent. humidity and at standard temperature, to have the products of combustion cooled to this same temperature and humidity, to separate out all drops of water, and to have the products of combustion occupy the same volume as the elements and at the same pressure. It is not hard to recognize the difficulties of this task. So we do the best we can and make corrections when necessary.

From the preceding facts regarding the action of the water molecules, it is evident that the water in an exploding boiler will tend to expand to the vapor pressure in the surrounding space. What this vapor pressure will be depends upon many factors, including the rate of removal of water vapor, the temperature, etc. It certainly is not correct to assume 14.7 lb. and 212 deg. without proof. And proof is impossible. The vapor pressure may be either greater or less than 14.7 lb. Then there is the other factor of violent actions tending to go through equilibrium to the opposite extreme.

History furnishes examples of peoples awfully oppressed, revolting, and when liberty is gained, temporarily turning it into license. A more technical example is a compressed spring; when the load is suddenly removed, the spring extends nearly as far as it had previously been compressed. There is no telling how gradually the pressure is relieved from the water in the exploding boiler, as it will build up vapor pressure in the immediate vicinity, set up waves of high and low pressures and otherwise introduce various conditions.

[1] "Experimental Engineering," Carpenter and Diedericks, p. 467.

Some Air Machine

According to a newspaper clipping, Benjamin Q. P. Foss, of Philadelphia, is going to build an armored gyroscopic hydro-aëro-triplane that will cost $450,000, have an average speed of 350 miles an hour, a cruising radius of 65,000 miles, and can start from a point of departure and visit any city in the world without alighting for supplies. Incidentally, Foss has interested a life-insurance expert. Foss proposes to end the war within 60 days after completing the machine. It is to remain stationary over the Krupp works at Essen, and demolish them with a preparation 300 times more powerful than dynamite. At Kiel and Helgoland, the German navy and its naval base will be demolished. There will be a storage capacity of 40,500 gal. of gasoline to feed the combined engine horsepower of 28,500. The machine is to be capable of making 500 miles per hour. The driving and lifting power are to be furnished by several four-bladed propellers 60 ft. in diameter, with a velocity of 1800 r.p.m. normal speed and 2800 r.p.m. when flying at maximum. A 60-in. propeller would be 188.5 in. in circumference and at 1800 r.p.m. would have a rim speed of 330,291 ft., or 64 miles per minute.

The Electrical Study Course—Complex Circuits

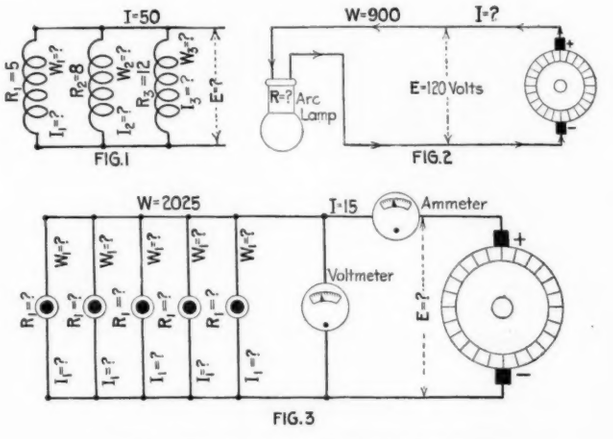
The problems given in the lesson on watts and kilowatts are worked out and then other problems explained involving complex circuits.

THE first step in the solution of problem 1 given in the previous lesson is to lay it out in a diagram, as in Fig. 1. Next find the joint resistance of the three circuits.

$$R = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} = \frac{1}{\frac{1}{5}+\frac{1}{8}+\frac{1}{12}} = \frac{1}{\frac{49}{120}} = \frac{120}{49} = 2.45 \text{ ohms}$$

The total voltage, $E = RI = 2.45 = 50 = 122.5$ volts. The current through each of the individual circuits is, $I_1 = \frac{E}{R_1} = \frac{122.5}{5} = 24.5$ amperes; $I_2 = \frac{E}{R_2} = \frac{122.5}{8} = 15.3$ amperes; and $I_3 = \frac{E}{R_3} = \frac{122.5}{12} = 10.2$ amperes. Checking up the results, the total current $I = I_1 + I_2 + I_3 = 24.5 + 15.3 + 10.2 = 50$ amperes as given in the problem.

The watts in the respective circuits are, $W_1 = EI_1 = 122.5 \times 24.5 = 3001.25$ watts; $W_2 = EI_2 = 122.5 \times 15.3 = 1874.25$; and $W_3 = EI_3 = 122.5 \times 10.2 = 1249.50$ watts. The total watts, $W = EI = 122.5 \times 50 = 6125$, or $W = W_1 + W_2 + W_3 = 3001.25 + 1874.25 + 1249.50 = 6125$ watts; either method



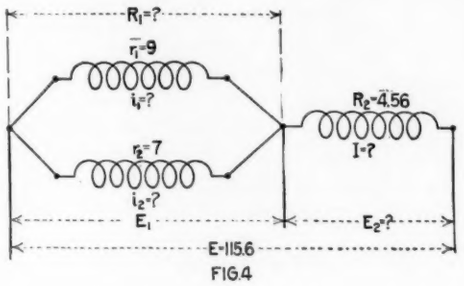
FIGS. 1 TO 3. ELEMENTARY CIRCUITS

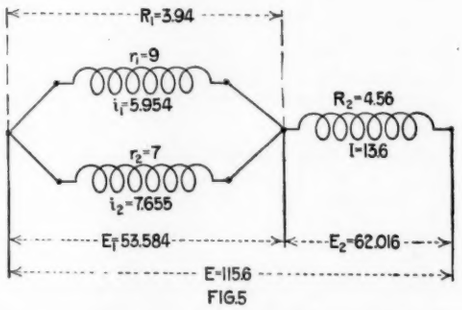
Fig. 1—Three resistances connected in parallel. Fig. 2—Arc lamp connected to source of voltage. Fig. 3—Five incandescent lamps connected in parallel

gives the same result. The total electrical horsepower $= \frac{W}{746} = \frac{6125}{746} = 8.2$ horsepower, and kilowatts $= \frac{W}{1000} = \frac{6125}{1000} = 6.125$ kilowatts.

The diagram, Fig. 2, gives the values in problem 2. The current taken by the lamp is $I = \frac{W}{E} = \frac{900}{120} = 7.5$ amperes, and the resistance $R = \frac{E}{I} = \frac{120}{7.5} = 16$ ohms. The resistance in this problem can be found direct from the watts and current. In the previous lesson we found that $W = I^2R$, hence $R = \frac{W}{I^2} = \frac{900}{7.5 \times 7.5} = 16$ ohms.

The incandescent-lamp arrangement of problem 3 is





FIGS. 4 AND 5. TWO RESISTANCE CONNECTED IN PARALLEL AND IN SERIES

given in Fig. 3. The line voltage $E = \frac{W}{I} = \frac{2025}{15} = 135$ volts. Then the joint resistance of the five lamps in parallel is by Ohm's law, $R = \frac{E}{I} = \frac{135}{15} = 9$ ohms. The current taken by each lamp will be one-fifth of that taken by the five, or $\frac{15}{5} = 3$ amperes; that is, $I_1 = 3$ amperes. The joint resistance may also be determined by $R = \frac{W}{I^2} = \frac{2025}{15 \times 15} = 9$ ohms. The resistance of each lamp is equal to the joint resistance of the group multiplied by the number in parallel, or in this case, $9 \times 5 = 45$ ohms. The resistance of one lamp may also be found by Ohm's law, $R_1 = \frac{E}{I_1} = \frac{135}{3} = 45$ ohms. This checks with the foregoing method. The rating of these lamps in watts is $W_1 = EI_1 = 135 \times 3 = 405$ watts. This value may also be determined by dividing the total watts taken by the group, by the number of lamps connected in parallel, or in this problem, $\frac{2025}{5} = 405$ watts. Total electrical horsepower $= \frac{W}{746} = \frac{2025}{746} = 2.7$ horsepower; and kilowatts $= \frac{W}{1000} = \frac{2025}{1000} = 2.025$ kilowatts.

So far our studies have been confined to simple parallel and series circuits. Frequently, conditions arise in practice where complex circuits are involved; that is, circuits in which elements are grouped in both series and parallel. For example, in Fig. 4, r_1 and

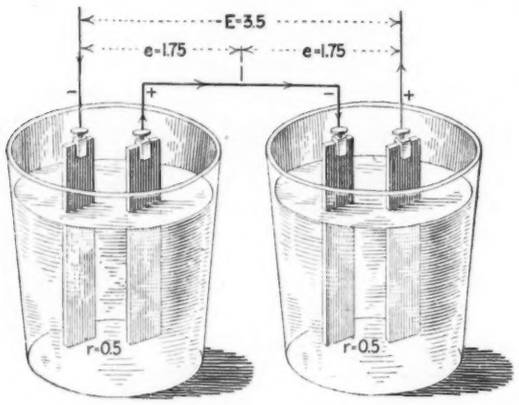


FIG. 6. TWO VOLTAIC CELLS CONNECTED IN SERIES

r_2 are connected in parallel and the group is connected in series with R_2. To find the combined resistance of such a group of elements, it is first necessary to find the joint resistance R_1 of the parallel connected group.

$$R_1 = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{1}{\frac{1}{9} + \frac{1}{7}} = \frac{1}{\frac{16}{63}} = \frac{63}{16} = 3.94 \text{ ohms}$$

The total resistance $R = R_1 + R_2 = 3.94 + 4.56 = 8.5$ ohms. The total current $I = \frac{E}{R} = \frac{115.6}{8.5} = 13.6$ amperes. Knowing the current and the resistance, we can find the volts drop across each section. By Ohm's law the volt drop across R_1 is $E_1 = R_1 I = 3.94 \times 13.6 = 53.584$ volts, and the volt drop across R_2 is $E_2 = R_2 I = 4.56 \times 13.6 = 62.016$ volts. Adding these results, the total volts $E = E_1 + E_2 = 53.584 + 62.016 = 115.6$ volts, the same as given in Figs. 4 and 5.

The total current, 13.6 amperes, flows through R_2, but divides in section R_1, part of it flowing through r_1 and part through r_2. The value of the current in r_1 and r_2 may be determined by Ohm's law, since we know the resistance of each branch and the volt drop. The current flowing in r_1 is, $i_1 = \frac{E_1}{r_1} = \frac{53.584}{9} = 5.954$ amperes, and the current in r_2 is $i_2 = \frac{E_1}{r_2} = \frac{53.584}{7} = 7.655$ amperes. Adding these results, the total current $I = i_1 + i_2 = 5.954 + 7.655 = 13.609$ amperes against 13.6.

A practical application on this problem is given in Figs. 6 and 7. Fig. 6 shows two battery cells connected in series. Each cell has a normal voltage, $e = 1.75$ volts and an internal resistance $r = 0.5$ ohm. The two cells when connected in series will give a normal voltage $E = 1.75 + 1.75 = 3.50$ volts. When the cells are connected to an external circuit, the total pressure will not be effective in setting up a current because it will require part of the volts to cause the current to flow through the internal resistance of the cells. This condition is similar to that in all power machinery. For example, if in the cylinder of a steam engine there is developed 100 hp., all the 100 hp. will not be delivered at the flywheel. Part of the power developed in the cylinder will be used to overcome the opposition offered by the various parts of the engine itself. Likewise for a motor, if 6 hp. of electrical energy is supplied to a motor, it will not develop 6 hp. at its pulley, but only about 5 hp. This means approximately 1 hp. is required to overcome the friction of the moving parts of the motor and other losses. The foregoing is just the condition we have in any source of electrical energy. That is, the total power produced in the device is not available at its terminal, as we shall see from a consideration of the latter circuit.

In Fig. 7 are shown the cells of Fig. 6 connected to an external circuit of two resistances in parallel. The joint resistance of the external circuit is $R_1 = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{1}{\frac{1}{5} + \frac{1}{3}} = \frac{15}{8} = 1.875$ ohms. The internal resistance of the two cells in series is $R_2 = r + r = 0.5 + 0.5 = 1$ ohm, and the total resistance is $R = R_1 + R_2 = 1.875 + 1 = 2.875$ ohms.

Tracing the circuit from the positive terminal in Fig. 7 through the resistances r_1 and r_2 back through

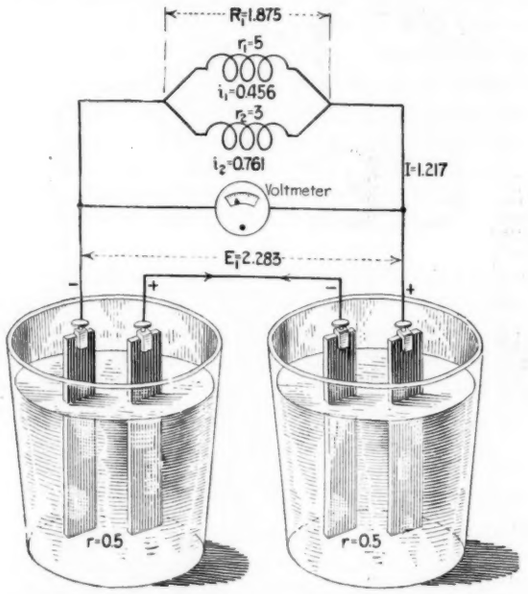


FIG. 7. TWO VOLTAIC CELLS CONNECTED IN SERIES AND TO TWO RESISTANCES IN PARALLEL

the cells to the positive terminal, we have a condition similar to that given in Fig. 5; that is, two resistances connecting in parallel in series with a third element. However, we neglected the resistance of the source of electromotive force in Figs. 4 and 5 and considered the voltage constant at the terminals of the resistance, which is practically so in light and power circuits, and is accomplished by some automatic means in the generator or on the circuit.

To find the current flowing in the circuit, the same method is used in Fig. 6 as in Fig. 5; namely, dividing the total volts by the total resistance. The total pressure is $E = 3.5$, the open-circuit volts of the battery, and the total resistance is $R = 2.875$. Hence, $I = \frac{E}{R} = \frac{3.5}{2.875} = 1.217$ amperes. To cause the current, $I = 1.217$ amperes, to flow through the battery resist-

ance, $R_2 = 1$ ohm, will require by Ohm's law a voltage, $E_2 = R_2 I = 1 \times 1.217 = 1.217$ volts. This will leave available a voltage E_1 at the terminals of the battery, which is equal to the total pressure, $E = 3.5$, minus the volts used to cause the current to flow through the battery, or, $E_1 = E - E_2 = 3.5 - 1.217 = 2.283$ volts, as indicated in the figure. By applying Ohm's law to the external circuit, the current flowing through the external circuit is $I = \frac{E_1}{R_1} = \frac{2.283}{1.875} = 1.217$ amperes, which is the same as obtained by the previous method. We may now find the current i_1 in r_1 and i_2 in r_2. $i_1 = \frac{E_1}{r_1} = \frac{2.283}{5} = 0.456$ amperes; $i_2 = \frac{E_1}{r_2} = \frac{2.283}{3} = 0.761$ amperes; and $I = i_1 + i_2 = 0.456 + 0.761 = 1.217$ amperes.

The volts drop in a voltaic cell or any other source of electromotive force cannot be measured directly by a voltmeter, but must be calculated as in the foregoing. The volts drop may also be obtained by measuring the open-circuit voltage with a voltmeter, which in Fig. 6 would be 3.5 volts, and then measuring the voltage with the load connected as in Fig. 7. This will give the pressure effective in causing current to flow through the load. In Fig. 7 the voltmeter should read 2.283, and the difference between these two readings gives the volts drop through the cells, or 3.5 — 2.283 = 1.217 volts. This corresponds with the calculated value previously obtained.

One feature in these problems that stands out more prominent than any other is that it does not make any

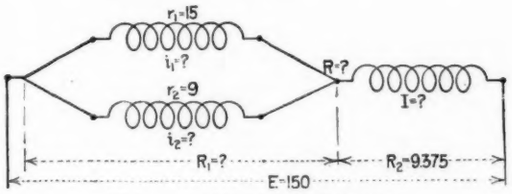


FIG. 8. COMPLEX CIRCUIT

difference how the results are arrived at, when correct they will always satisfy Ohm's law.

The study problems are as follows:

1. A voltaic cell has a normal open-circuit voltage of 1.8 volts. Its internal resistance is 0.4 ohm. Find the current that this cell will cause to flow through the coil of a bell that has 2.6 ohms, also find the voltage.

2. If the armature of a generator has 0.25 ohm resistance, what voltage must it produce to cause a current of 35 amperes to flow through 4.75 ohms? Find the value of the volts at the armature terminals when the current is flowing; the watt, kilowatt, electrical horsepower supplied to the load and the watt loss in the armature.

3. Find the values indicated by the interrogation marks on Fig. 8.

According to the Commerce Reports, The Unión Eléctrica Española publishes statistics showing that 170 hydro-electric plants are operated in Spain, having a total of 881,174 hp. available, of which 384,279 hp. is developed. As the figures given do not include all such plants, it is estimated that the total power exploited is about 400,000 hp. and will reach 500,000 hp. when work already under way has been completed.

Moisture in Compressed Air

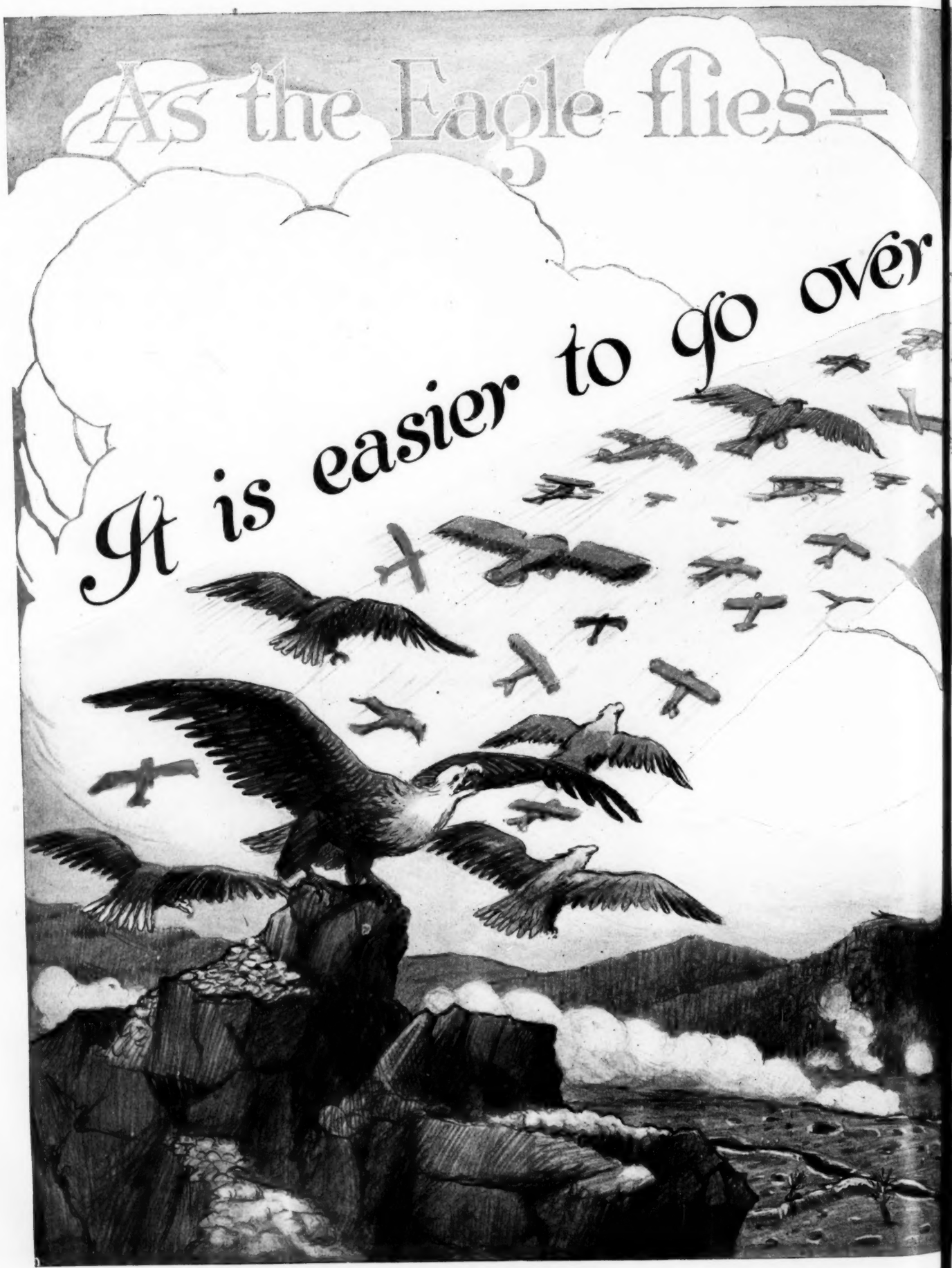
By R. S. Hawley

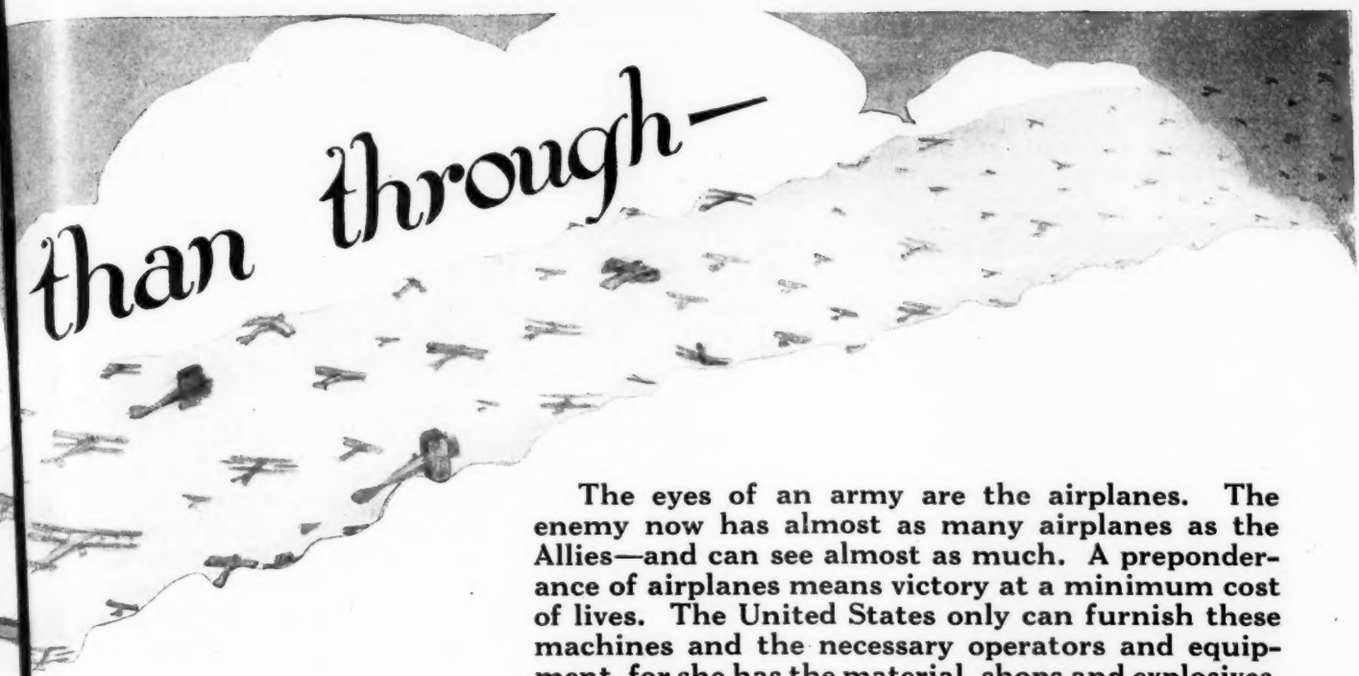
Moisture is always present in the atmosphere in greater or less quantity, depending on locality, altitude and general surrounding conditions, and will therefore be present in compressed air, and unless eliminated, it will be carried along with the compressed air and be present when the air is used in pumps, drills or other machines. The troubles arising from moisture, particularly freezing, can be avoided to a great extent by removing it by mechanical means or by heating it so it will be above freezing temperature when exhausted.

If 10 cu.ft. of atmospheric air is compressed to a volume of 2 cu.ft. and its temperature remains the same, its capacity for holding moisture is reduced to one-fifth of its original capacity. However, while air is being compressed its temperature tends to rise directly with the pressure, and warm air will hold more moisture than the same volume of cold air. If air is compressed and its temperature afterward reduced, as much of the moisture will be precipitated (in the form of water) as is in excess of the carrying capacity of the air at the temperature. This water can be drained from the intercooler or receiver. This occurs to a considerable extent with multi-stage compressors having intercoolers and aftercoolers. Placing a receiver of fairly large capacity near the compressor will give good results because the air will circulate and cool considerably. A drain, or better, an automatic trap should be connected on the bottom of the receiver or cooler to discharge the water without the loss of air, and the main air-pipe connection should always leave the receiver from a point near the top and be arranged in such a manner as to cause the air to change its direction abruptly, for if air flowing at high velocity, suddenly changes direction or strikes a baffle plate or is given a whirl, there is a tendency for the moisture to be separated from it and to be deposited in the bottom of the receptacle. This action is similar to that of the ordinary steam separator and will help eliminate the moisture in compressed air.

Moisture Not Eliminated by Reheating

Reheating compressed air does not eliminate moisture; in fact, it puts the air in a condition to take up more moisture if it were present. However, with only a given amount of moisture present, the percentage of moisture is less when the volume of air is increased by reheating. The important thing about reheating in this connection is to raise the temperature of the air to such a point that when it is used in a pump, drill, hoist or other machinery, the moisture will not freeze at the exhaust, even though the atmospheric temperature be very low and the air is used expansively. It should be kept in mind that air, when expanding, tends to decrease its temperature in the same ratio as it was increased when compressing. Therefore the exhaust air is likely to be below freezing temperature, and any moisture will freeze around the exhaust pipe or port of the engine. Reheating may be done by the use of steam coils, coal or oil or gas burners, and the temperature of the air regulated to suit. Temperatures up to 300 deg. F. are common.


As the Eagle flies—
It is easier to go over



than through—

The eyes of an army are the airplanes. The enemy now has almost as many airplanes as the Allies—and can see almost as much. A preponderance of airplanes means victory at a minimum cost of lives. The United States only can furnish these machines and the necessary operators and equipment, for she has the material, shops and explosives. We need 50,000 machines and 10,000 aviators quickly—every day's delay means sacrificing the lives of thousands of our soldiers.

Fortifications of concrete, trenches, wire entanglements and all such obstacles mean a frightful loss of life to overcome by going *through* them, but by going *over* them in such numbers as to put the enemy airplanes completely out of action, explosives may be dropped on enemy batteries, transport lines, submarine bases, manufacturing plants, munition depots, battleships or troops at will.

Blind the eyes of the enemy by overwhelming his air squadrons, and we will win with the smallest loss of life.

Girtanner-Miller Arch Brackets

Improved iron brackets for different sizes and makes of flat arches for boiler furnaces are being made by the Fred Girtanner Co., Chemical Building, St. Louis, Mo. The various types are shown in the accompanying illustrations. The feature in each case is a removable clip

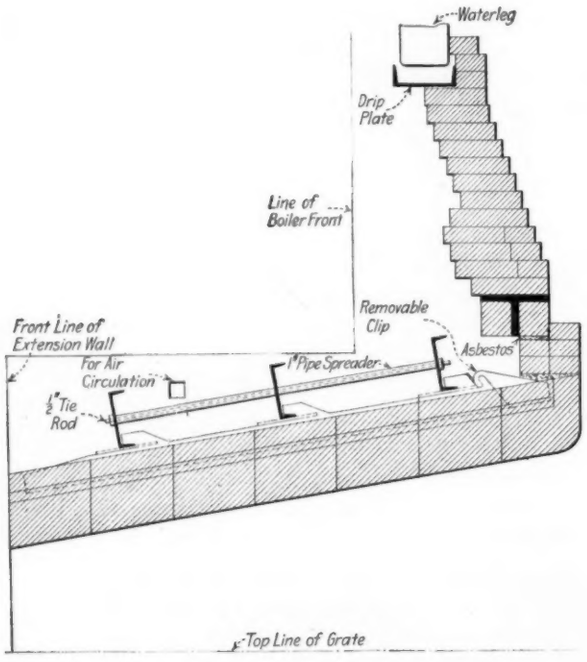


FIG. 1. COMPLETED ARCH CONSTRUCTION

at the inner end of the bracket. It is here that the arch is exposed to the greatest heat, and the end tiles are the first to deteriorate. That part of the arch nearest the

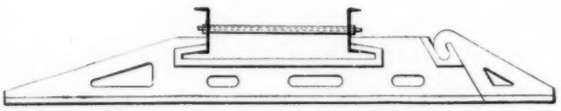


FIG. 2. A 5-FT. ARCH BRACKET

fuel supply is seldom damaged by the fire. To avoid the necessity of removing and rebuilding the entire arch when the inner-end tiles are destroyed, the removable

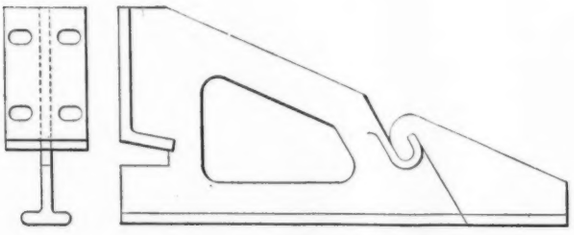


FIG. 3. ELEMENT OF TWO-PART BRACKET

clip at the end of the bracket has been provided. With this arrangement the end tiles can be easily removed and replaced, each independently of the other. The clip is hung at an angle of 60 deg. so that there is little strain on the hook securing the clip to the bracket.

Fig. 4 shows a 6-ft. 6-in. bracket supported by three channels. These channels are tied together with spreaders between to hold them in place, as indicated in Fig. 1. A 5-ft. arch supported on channels or I-beams is shown in Fig. 2. In the design illustrated in Fig. 3

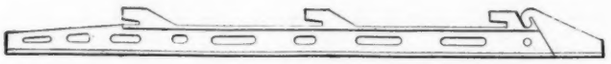
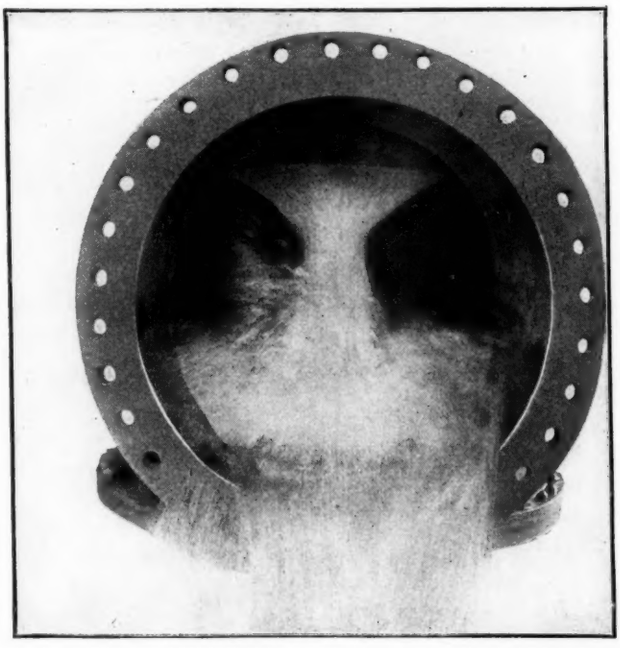


FIG. 4. THREE-CHANNEL BRACKET

the bracket is in two parts bolted on either side of a central I-beam. Fig. 1 shows a completed arch supported by a bracket of the design indicated in Fig. 4.

Novel Photograph of Check Valve

The accompanying photograph is an oddity taken at the works of the G. M. Davis Regulator Co., Chicago. The picture shows the inlet end of a 20-in. check valve. As may be remembered by the reader, this type of valve has a horizontal disk seating near the center of the valve body. When the valve is in service, water comes in underneath the disk, passes up through the circular



PECULIAR FLOW OF WATER THROUGH A CHECK VALVE

port and out through the other end of the valve. To hold the disk in place a rod or stem passes up through the valve body, with a handwheel below to raise the disk by hand if desired.

In the picture the inlet end of the valve has been disconnected and the disk has been raised by means of the handwheel. Water is flowing back through the circular port, and instead of dropping down straight in the form of a cylinder, its outline approximates a cone. The stem of the disk running vertically through the valve body no doubt prevents a sharper apex. The shape of the port and atmospheric pressure may have something to do with the peculiar form taken by the water. The photograph at any rate is unusual and for this reason is presented.

Editorials

Start the Eagle Flying

A MAN who has since become very successful in the business world once said, "I know that I don't always decide right, but I am able to decide somehow."

Decision—action—getting into motion toward the desired object is what tells. The man who starts something somehow, gets somewhere even if he doesn't go in the most direct line; the man who is unable to decide simply founders and gets mired deeper and deeper.

In a time of war, especially, decision must be quick and positive. One general who can use his troops promptly is worth more than a council of twenty brighter men who cannot agree. In this respect an autocracy is vastly superior to a democracy; not that a democracy cannot fight, when it has decided that it has to and how it will go about it, but it takes so long to make up its many-parted mind, and so much can be done by a quickly moving enemy while deliberate democracy is getting around to it. All that would be necessary for a far-seeing enemy to do would be to engraft one of his minions in a democracy, fit him out with a chain of newspapers made popular by an artful solicitude for the interest of the people, secure with their aid the election of a handful of willful men to the Senate, and he could keep the composite government in such a torment of indecision as would enable him to twirl about his thumb a people which, could it use its resources promptly and effectively, could rule him off the earth.

Two years ago the coming need for ships was apparent. A year ago it was pressing. Today it is crushing. We have got to have ships. Is every shipyard in the country working day and night, turning them out in wood as well as in steel? Oh, no! Mr. Denman and Mr. Goethals are discussing whether it is desirable to build wooden ships at all, and somebody else is discussing whether it is better to work the men *overtime*.

The airplane, an American invention, is the eyes of the army. If one side is predominant in the air, it will have a vast advantage upon the ground. The best service that America can render to the allied forces is to set our resources at work turning out airplanes, and training men to run them. Every material, every facility, every attribute necessary for the making and operating of airplanes are at our disposal; American standardization methods, American ingenuity, American machine shops can turn out such a swarm of airplanes as will enable the armies of the entente to put out the eyes of the serpent that is trailing across Europe and reduce the efficiency of its return strokes. Every plane and every flier that we can send over will save on an average the lives of many men. If they were over there now, they would be saving lives and winning the war. Are we going to begin to make them tomorrow? Oh, no! we have got to make up our minds first whether it is best to do it at all, and if so, how best to do it, and then we shall have to have an appropriation of perhaps a billion dollars, and the Kaiser's friends in the House and Senate will bat the bill back and forth, and battle and delay and filibuster, so that by the time we could, if we started now, be sending help in the most welcome and efficient form, we shall just about be getting ready to begin.

Ford turns out over three thousand complete automobiles a day. How many airplanes could the Americans turn out, man and send to Europe, if all their resources were directed most effectively and efficiently toward that purpose?

Hindenburg lies across Europe, dug in, cemented in, moved back a few paces at a time by the expenditure of thousands of lives and a wealth of ammunition. Germany has shown what can be effected by the ruthless use of a handful of airplanes. The easiest way to get through the Hindenburg line is to go over it, and it is the eagle that will do it. How long shall we be in turning him loose?

Why Change the Clock?

THE recent announcement that Senator William N. Calder of New York had sent word to the National Association of Daylight Saving that he would amend the bill he has introduced before Congress to have the clocks throughout the country set ahead one hour, as a war-time necessity, so that the measure may become effective as soon as the law is enacted, instead of January 1, 1918, as now proposed in the bill, brings to notice a controversy that has been agitating the minds of the people of the European and American continents for a number of years.

The daylight-saving movement took on a serious aspect during 1910 and 1911 in England, when attempts were made to have it enacted into a law. However, these attempts were at that time defeated. Some of the objections raised against such a statute were that it would be detrimental to the interests of the central stations, gas companies and candlemakers, as well as infringing upon the sentiments of the people. When the war broke out and it became necessary to economize in fuel as well as in every other necessity, the question of using the daylight to better advantage was again introduced, and last year a law was passed requiring that all industries set their clocks ahead one hour. Which reminds us that the stern necessities of war are no respecters of private interests or personal sentiment. Almost every European nation has enacted similar laws.

But why all this agitation about moving the clock ahead when there is nothing wrong with the clock. The trouble is with ourselves. Our ancestors' day of work was from sunrise to sunset; this brought noon in the middle of his day. When hours of labor were first established, they were from six a.m. to six p.m.; this made the axis of the day's work coincide with the

noon hour. However, as the hours per day of labor were reduced, this balance was not maintained, and now when the eight and the nine-hour day are in general use, we find its axis shifted from one to one and one-half hours past twelve noon; that is, we are beginning work at eight and nine o'clock and quitting at five, when our activities should begin at seven thirty or eight and end at four or four thirty. Or whatever the hours may be, twelve noon should be the center of this period. Therefore why try to fool ourselves into getting started to work an hour earlier in the morning by shifting the clock ahead one hour. Why not correct our working day by bringing its axis to coincide with the center of the daylight period where it originally was.

The bad effect of shifting the day-period working hours ahead into the night as at present is apparent on every central-station or industrial power-plant load curve, with its extremely high peak around five p.m. during the winter months when the industrial load overlaps the lighting load, and reaches a maximum during the month of December, when the daylight period is the shortest.

Practically ever since the beginning of the electrical central-station industry, one of the big problems to the operating man has been how to fill up the valleys in the load curve and bring them up to approximate the peaks, as the maximum load determines the necessary generating and distributing equipment and consequently the cost of energy. A consideration of the "Northern Lighting Schedule Chart," published in the issue of June fifth, which is based on the N. E. L. A. Northern Schedule and is correct for the northern states of this country and the southern part of Canada, shows that the lighting time for the month of December, the month having the shortest daylight period, is from about five p.m. to six thirty a.m. This gives about ten and one-half hours of daylight throughout this region, which embraces practically all the northern industrial district in North America; yet, with a minimum of ten and one-half hours of daylight to do eight or nine hours' work in, we have been running over into the night, with the result that we have been working under artificial light when daylight could have been used, and the cost of power has been increased owing to the necessity of installing additional plant equipment to carry the peak where the lighting load overlaps the industrial, not to mention the unnecessary burning of thousands of tons of fuel.

If the valleys in the load curve cannot be built up to approximate the peaks, why not cut the peaks off by shifting the industrial load back to where it belongs? If sunlight is preferred to artificial lighting, why not make more use of the sunlight by beginning our daily activities at the proper time? If we wish to conserve our fuel resources and are in earnest, let us prove it by making more use of the daylight—not only now as a war necessity, but in the future as an economical prerequisite to prosperity in time of peace. Therefore if we are going to have a daylight-saving law, let it not be one for shifting the hour hand of the clock ahead, which is comparatively correct at present, but let us legislate the center of the working day to the center of the daylight period, which is twelve noon and not eleven a.m.

The Outlook for Welding

Engineers are well on the way toward giving welding, particularly as applied to pressure vessels, the attention that it needs before it can have wide adoption for this class of work. In the refrigeration industry welding is attractive for the pressure vessels used; but owing to the extremely high pressures to which these vessels, receivers particularly, may be subjected, serious objection has been raised against the application of welding.

The Municipal Regulations Committee of the American Society of Refrigerating Engineers did well in appointing a subcommittee on welding, at whose hands the subject will receive conservative attention.

Another welding meeting of note was that recently held at the United Engineering Societies Building, under the direction of the Compressed Air Society. The most pleasing feature of the meeting was the hearty coöperation given by manufacturers and welders. These men expressed their knowledge of the weaknesses of welds and further expressed their hope that some movement might be quickly set on foot to investigate the reasons for failures of welds and to establish some better means of testing them. It was agreed to appoint a committee made up of representatives of all the interests concerned. The hope is to soon present to the Boiler Code Committee of the A.S.M.E., a proposed code on welding as applied to pressure vessels.

Tom Hunter Back Again

The return of Tom Hunter, Hoisting Engineer, will doubtless be welcomed by hoisting engineers and others employed about the steam plants of various kinds of mining enterprises. The series of about twenty-four articles, the first of which appears in this issue, deals briefly with the early history of iron and copper mining in the peninsular region of Michigan, and also tells about the various types of hoisting engines and air compresors found in that section.

Some of the largest hoists and some of the most economical air-compressor units in the world are described, and many illustrations of these and other interesting apparatus accompany the articles. Some of these hoists are of more than eight thousand horsepower capacity, some of the hoisting speeds are more than a mile a minute and several of the shafts are in the neighborhood of eight thousand feet deep.

Engineers for Merchant Marine

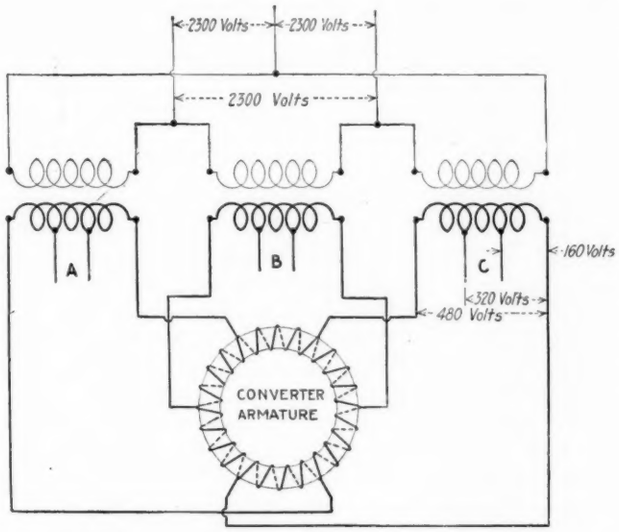
Seldom an opportunity is available equal to that offered by the Government, through the Shipping Board, for men to qualify for marine engineers and navigators. It is not expected that all applicants will be considered fit material, nor will the "hot house" product supplant the "old salt" instanter. There are, however, two outstanding features, the reduction in service requirement and intensive training at Government expense to compensate for lack of sailing experience. The fact that no enlistment is required, dependence being placed on the attractiveness of the service and pay to hold the men, shows what the officials think of the future. The call is expected to bring without marine experience.

Correspondence

Transformer Breakdown

One morning recently our 300-kw. rotary converter, used for supplying power to a 600-volt railway system from a 2300-volt three-phase alternating-current line, refused to start, and when the starting switches were closed, it simply oscillated back and forth through a small part of a revolution.

The accompanying diagram shows a layout of the connections for the stepdown transformer and the converter in question. The transformer is a three-phase, oil-insulated, water-cooled unit. The core, winding and cooling coils are supported from the heavy cast-iron cover. The leads from the primary coils come out at the top of the winding, while the secondary leads are brought out at the bottom of the coils and carried up around the core to the terminal board at the top of the transformer. Taps are brought out from the secondary coils in two places to provide 160-volt and 320-volt current for starting, the full voltage across the secondary terminals being 480 volts.



SCHEMATIC CONNECTIONS OF THE TRANSFORMER AND ROTARY CONVERTER

The action of the rotary when attempts were made to start it led us to believe that one phase was open at some point. Examination of the converter did not disclose any fault, and attention was then given to the transformer connections. Testing the secondary winding showed each phase to be badly grounded. Consequently the only solution was to raise the core and coils out of the case, which necessitated moving the whole transformer out on the floor, as it was in a position over which the headroom was not sufficient.

Unfortunately, we did not have an overhead crane, so we were obliged to use cribbing and jacks for raising the core and coils, which was a job that took the greater part of two days. When the core was raised to a sufficient height to allow inspection of the secondary leads, it was discovered that two terminals of one phase and one terminal of another phase were burned off, which accounted for the open phase.

In some unaccountable manner, water had got into the oil with which the transformers were filled and had settled to the bottom and soaked through the insulation, practically short-circuiting the secondary coils through the water.

It would be interesting to know just what had occurred, as none of the cables making up the secondary leads showed the effects of having been burned, but rather, were bright, as though having been immersed in acid. Sections of the leads from 4 to 6 in. long were entirely gone, yet the ends did not have the appearance of having been burned.

The leads were grouped and taped in such a manner that it was impossible to tell which ends had been connected together. There were 12 leads from the secondary coils to the terminal boards at the top of the transformer, and it was necessary to separate all the leads and ascertain how the undamaged phases were connected. Connecting the damaged phases in a like manner produced the desired result, for after the transformer was repaired, it was put into service without further trouble.

Repairs were made by our own engine-room force with the exception of some help from our linemen in slicing the cables. The job was completed and the transformer ready for service in about fifty hours. Before placing the transformer in service again it was filled with new oil, as the old oil was found to be low in insulating quality, breaking down at about 4400 volts.

Ithaca, N. Y. C. B. HUDSON.

Liquid Level in the Ammonia Receiver

The experience related in the May 29 issue by V. O. Safranck of trouble with an ammonia condenser is one that has vexed many refrigerating-plant operators. My firs' experience of this kind was with two 200-ton machines discharging into a single large condenser. During warm weather I had no difficulty, but as soon as I could handle the load with a single machine the trouble began. When I shut down one of the machines—it made no difference which one—the ammonia would begin to disappear from the receiver. In about four or five hours it would be gone entirely and the frost would begin to vanish from the suction side of the machine. This would continue until the temperature of the suction gas would be from 10 to 15 deg. above that corresponding to the suction pressure.

The first time that this happened we assumed that the system needed ammonia and we put in several hundred pounds, but without effect. We ran several days without a sign of frost on the suction side of the machine, but finally the weather turned warmer and we had to start

the other machine to keep down the temperatures. As soon as the second machine was started, the liquid receiver began to fill and in about fifteen minutes the suction lines to both machines were frosted. After about half an hour's run the receiver was nearly full of liquid.

The next time we shut down one of the machines, the same thing happened. Not only did the liquid disappear from the receiver and the frost from the suction line, but the liquid line at the ice tanks began to get covered with a thin, slushy frost. The expansion valves were frosted way up on the stems, and nobody was able to account for it. Another peculiar thing was that at first the condenser pressure would drop to about 120 lb. immediately after the one machine was shut down, but would "crawl" up again to the 150 lb. usually carried when the two machines were running. We tried everything we could think of to bring the liquid back again, but without results. The only thing that did any good was to pump down. We did, and the liquid disappeared.

Finally I turned my attention to the condenser. In going over this, I found that about half of the stands were cold while others were hot. Generally, when this happens I have found that it is a sign that the system has considerable air in it, so I purged the coils, one at a time. This helped, as the frost disappeared from the liquid line on the tanks and the suction line also frosted again. This brought down the brine temperature.

Going over the condenser a little later, I found many coils still cold. I decided to experiment a little, so I shut off the cold coils, one at a time, and pumped them out. After I had pumped out about one-third of them, the liquid came down in the receiver in slugs until it was nearly full. The condenser pressure also dropped from about 150 to 135 lb. In a short time the machine was heavily frosted and we had to close off considerably on the expansion valves before we got the pressure back to normal temperature.

Cut in One Coil at a Time

This led to further experiments. First I tried to cut in all the condenser coils again, but it was only an hour or two until the liquid disappeared from the receiver and they had to be cut out again. After I had them pumped out the second time, I tried cutting in one coil at a time to see how many I could use without causing trouble. Here is where I met some more surprises. Some of the coils I could cut in and work without trouble, but others, when I cut them in, would not only stop working and turn cold in a short time, but seemed to affect some of the others, as evidenced by their turning cold and by a reduction of the quantity of liquid in the receiver.

After experimenting for several days, I found that I could run with one-quarter of the coils cut out, and these were grouped close to where the discharge line from the machine connected to the condenser header. By running in this manner I could maintain a condenser pressure of about 125 lb. and keep the receiver practically full of liquid. If I tried to run any other way, the head pressure would go up, some of the coils would begin to get cold and the liquid level in the receiver would lower.

When the machines were changed over, I got into trouble again. This time another set of coils refused to work and I had to cut them out and cut in those that had been out when the other machine was running. This time, too, it was the coils close to the discharge of the machine. One thing I found in either case: there was always more or less air or foul gas in the dead coils. Purging these always helped for a while, but they invariably refused to work for any length of time. The discharge connection for both machines was at the bottom of the header, and the branches for each stand were also taken from the same side, and I have often wondered if this could have had anything to do with it.

Minneapolis, Minn. E. W. Miller.

Cleaning Surface Condensers

In trying to get some information on the subject of condenser cleaning, we sent out a circular letter addressed to the chief engineers of various plants. We asked a series of thirteen questions on the subject of their condenser cleaning and think the results will be of interest to those in any way connected with the care and operation of condensers.

Out of 247 letters sent, answers were received to 62. Of this number 16, for one reason or another, did not give any information, quite a few of them not having any condensers. Forty-four filled in more or less of the information we asked. Of this number 41 were using our condenser cleaners. Of the 44 that gave information, 14 were ice plants; the other 30 were power plants, using surface condensers. In endeavoring to get some information of value from this collection of data, we have something like the following:

First, the question of how often it is found necessary to clean the condenser. We could not strike an average very well, as that would not mean anything, but we find 7 clean yearly, 14 clean two to four times a year, 2 clean monthly, 4 clean weekly. One plant washes out daily and bores out with the cleaner every three months. Another plant washes out every two weeks and bores yearly. One plant using acid for cleaning, cleans as often as possible. One cleans vertical condenser daily by means of a scraper, using the cleaner when the scale gets beyond the scraper. One Ziegler condenser user cleans all the time, claims that no other method than mechanical cleaning would do the work and that he has the worst water in the United States. Of those using Lagonda cleaners, the average time between cleaning is seven months, or they clean about twice a year.

Some of the other methods tried were "pulling," "the use of rods," "acid and boring," "washing and swabbing," "hose," "brushing," "scraping." None of these methods was pronounced good. One man said the use of acid was expensive and all the methods poor in comparison with mechanical cleaning.

We find that the interval for cleaning has a direct relation to the kind of deposit formed in the tube. Those having soft deposit do not have to clean so often, and they can use such methods as washing out, using the cleaner at longer intervals. The kind of deposit also has a direct bearing on the length of time it takes to clean a condenser. We find that the average time to clean a condenser with a cleaner is 27 hours. One man that cleans yearly (steam condenser in an ice plant) claims that it takes two weeks to clean his condenser. Then again, another engineer claims that he cleans his condenser every four months, taking two days for the

job, at a cost of $15. One man cleans every two weeks, and it takes only two hours to do the job and costs about $2. The time required to clean a tube averaged 5 minutes—from a minimum of 20 seconds up to 40 minutes—and of course this has a direct relation to the kind of deposit in the tube and the intervals at which the cleaning is done. One-third of the answers gave the time to clean a tube at one minute or fraction of a minute, but several very high estimates made the average run high. Eliminating six reports, the average time to clean a tube is two minutes.

We find the average cost of cleaning to be $25, depending again on the intervals of cleaning. One man cleans yearly, claiming that the job takes 144 hours at a cost of $125. Another cleans every two weeks, the job taking two hours and costing $2.

Boring Out Found Effective

Sixteen had tried other methods and found none so effective as boring out. One man, claiming the worst water in the United States, says, "No other method could do the work." One very interesting case is found at Hico, Tex. At this plant a hard scale $\frac{1}{32}$ in. thick forms in two weeks and they bore out every two weeks, the job taking only two hours. They have tried other methods and give as the result, "Same as nothing." They say that when $\frac{1}{32}$ in. of scale is formed, it is impossible to hold the vacuum.

We asked for the engineers' experience as to what effect scale had on the efficiency of a condenser. All agree that it rapidly cuts down efficiency in proportion to the amount of scale. Some of the answers as to the effect of scale were as follows: "Same as on boiler"; "Causes loss in vacuum"; "When vacuum drops $\frac{1}{4}$ in. it pays to clean"; "Slight scale reduces efficiency 18 to 20 per cent."; "Three weeks' collection lowers efficiency 30 per cent."; "$\frac{1}{32}$-in. scale reduces efficiency 10 per cent."; "We find that by cleaning a condenser the vacuum is raised an average of $4\frac{1}{2}$ in." One man claims that he raised the vacuum 12 in., and the lowest account is 1 in. Here is a good one as to effect of scale: "A probable increase in steam consumption of prime mover of 20 per cent. Decrease of rating of turbine or inability to pull rated load."

READINGS TAKEN BEFORE CLEANING

P.M.	Steam Pressure	Load, Kw.	Vacuum by Merc. Col.	Barometer	Suction	Discharged	Hot well
7:00	156	670	25.8	29.04	74	91	113
8:00	153	710	25.3	29.04	76	95	119
8:30	146	690	24.95	29.03	78	98	123
9:00	142	680	24.95	29.03	79	98	124
9:30	152	650	25.2	29.03	79	96	121
10:00	145	640	25.0	29.03	79	98	121
10:30	145	630	25.4	29.03	79	94	118
11:00	150	530	26.0	29.03	79	96	105

READINGS TAKEN AFTER CLEANING

6:30	145	550	26.9	29.08	69	82	86
7:30	155	690	26.9	29.06	71	86	97
8:00	154	710	26.85	29.06	72	87	99
8:30	152	700	26.7	29.05	73	89	101
9:00	148	660	26.7	29.05	75	90	101
9:30	147	660	26.7	29.05	75	89	98
10:00	154	670	26.7	29.05	75	90	100
10:30	160	635	26.75	29.05	75	88	97
11:00	160	520	26.6	29.07	74	86	88

This same engineer, in answer to our question as to the effect of cleaning on hotwell temperature and vacuum, gives the accompanying table of readings taken at his plant.

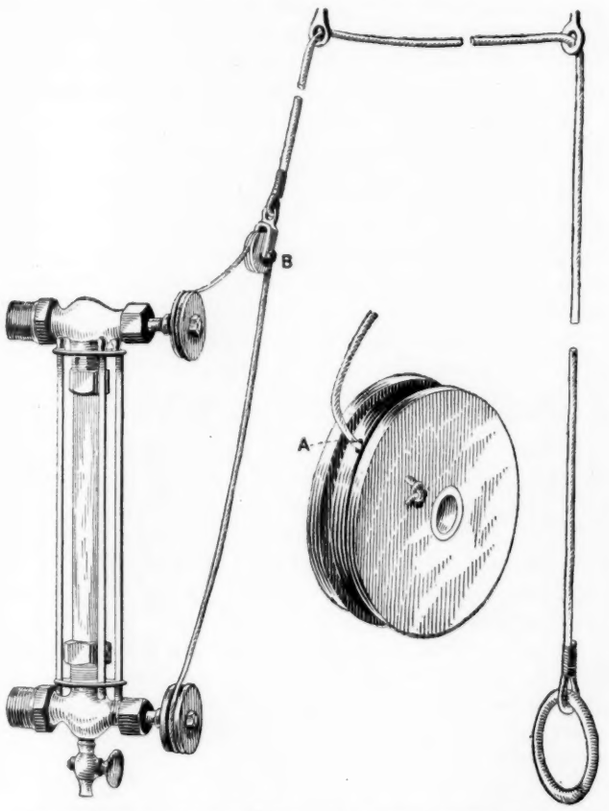
We find that cleaning will materially increase the vacuum and lower the hotwell temperature. One man gives his hotwell temperature before cleaning as 145 deg.; after cleaning, from 3 to 8 deg. above the intake. Another gives his hotwell temperature before cleaning at 100 deg. at 28 in. vacuum; after cleaning, 76 deg. at 29 in. vacuum, the temperature of the circulating water being 60 deg. Others give the lowering of the hotwell temperature at anywhere from 5 to 25 degrees.

M. M. Sellers,
The Lagonda Manufacturing Co
Springfield, Ohio.

Closing Gage-Glass Valves in an Emergency

A simple and cheap arrangement can be made for closing the valves of gage-glasses on boilers if the glass should blow out, and it is often up to the man in charge to provide things of this kind for his own safety.

Take two grooved wooden wheels about 3 in. in diameter and $\frac{1}{2}$ in. wide, drill a small hole as shown at *A*, fasten the ends of a small copper wire or strong



SHOWS HOW VALVES MAY BE CLOSED FROM A SAFE DISTANCE

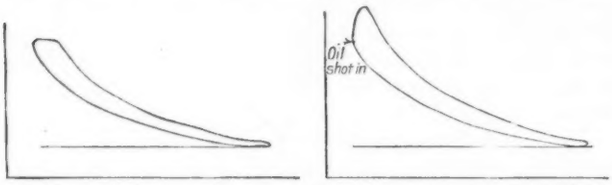
cord in the holes with sufficient slack to make about three turns on each wheel. Place a small grooved pulley *B* over the cord, as shown, to which attach a long cord extending through screw-eyes in the ceiling or beam above. By pulling down on the cord the valves are closed. The material for the whole job will cost only about 30 cents, and it will do the work just as well as an expensive outfit, as both valves will be closed instantly when the cord is pulled.

Toronto, Ont., Canada. J. O. McDonnell.

Semi-Diesel Engine

We have been having some discussion regarding the definition of a semi-Diesel engine. Two different statements of this class of engine have been offered, and I should like to get an expression of its meaning through the columns of *Power*.

One description of a semi-Diesel engine is one with a moderate compression pressure of, say, 250 lb., into which the oil is squirted under pressure or by compressed air from a receptacle, and which is exploded by some ignition device. The other idea of this type of engine is that the compression is high enough to ignite the oil as soon as it is injected into the chamber. The oil, however, instead of being injected for a definite



SLOW BURNING OF OIL INSTANTANEOUS BURNING

interval depending on the load on the engine, as in the standard Diesel cycle where the length of the upper line of the card is dependent on the load on the engine, is injected practically instantaneously from a receptacle in the cylinder, and instead of a slow burning of the oil, we have the equivalent of an explosion, for the pressure rises on the card very much as in gasoline engines.

The diagram sketches show what I mean by this difference in type. I hope that discussion will clear up the term, as I have found that engineers are not very clear as to just what is meant by the terms "semi-Diesel." A. G. CHRISTIE.

Baltimore, Md.

Putting in Large Gaskets Without Help

Having tried unsuccessfully, with twine and other similar devices, to hold the gasket in place while assembling a large centrifugal pump split vertically, I hit upon the following plan, which made it an easy one-man job notwithstanding the pump was about 4 ft. in diameter and consequently the gasket was heavy, flimsy and hard to manage.

I took a square piece of packing and placed it over the face of the pump and made a hole for one of the top bolts with a ball-peen hammer and drove in a soft-wood pin about an inch long and split out large enough to fit tightly in the bolt hole, leaving it protruding about a quarter of an inch, to hold the gasket firmly in place. Then stretching the gasket smoothly over the flange, I fastened it in like manner in as many places as necessary and cut out the remaining bolt holes and the center of the gasket with the hammer. It was then an easy matter to lift the other half of the pump with a chain-fall and place it against the stationary part so the bolt holes matched and to put bolts enough through the vacant holes to draw the parts firmly together. The wooden pins either entered the corresponding holes or were pushed through, but pinched the gasket enough to hold it in place. The pins were then punched out and the remaining bolts put in and drawn up.

There was no sagging, wrinkling or tearing of the gasket and clogging of the bolt holes. If one piece of gasket material is not large enough, one piece may be lapped over the other and held with the pins and cut dovetail with a sharp knife or chisel, and it will be perfectly tight. I have used this method on large pumps and condensers and without help, and I think it is by far the quickest way. J. R. CHAPMAN.

Fairfield, Me.

Heat from Excessive Oil

An instance that came to my attention of oil throwing from a telescopic oiler was due to the tubes being upside down; that is, the outside tube was screwed into the upper fitting and the inside tube into the lower fitting, and of course the oil worked out between them. Reversing the fittings cured the trouble. In another case there was no air vent at the top, and the telescopic action of the tubes caused the air to be forced in and out between the tubes, carrying considerable oil with it.

I read with interest the statement of Mr. Sheldon, in which he claims that the eccentric will not run as cool when a stream of oil is fed as when only two or three drops per minute are used. I have on two or three occasions noticed the same apparent action, but as it seemed contrary to the usual laws of engineering, I hesitated to mention it, thinking that it was probably due to my imagination.

The principle of lubrication is twofold. First, to reduce friction by forming a film of oil between the shaft and bearing surface. The least quantity that will maintain this condition is sufficient for lubrication. The second purpose of oil is to carry off the heat resulting from friction in the bearing, and in order to accomplish this several times as much oil is used as is actually needed to reduce friction. The surplus simply absorbs heat and flows out of the bearing. The reason that the bearing appears to be hotter when the greater amount of oil is used, is in my opinion this: When the oil supply is greatly increased, considerable of the heat that would otherwise be radiated by the metal is absorbed by the oil, which retains this heat and remains at more nearly the temperature of the bearing surface, which is higher than that of the outer surface. This greater quantity of oil flows out of the bearing in all directions and over all parts of the strap and, as it is at a higher temperature, heats the outside of the strap and leads to the impression that the bearing is actually hotter. In reality it simply brings the heat to the outside, making it appear to be at a higher temperature.

This in my opinion is the only way that it can occur, as the extra oil used cannot in itself cause friction and heating, and I believe that if the true temperature of the bearing surface could be determined it would be found lower where the maximum amount of oil was used for the reason that the heat of friction is carried away more rapidly than otherwise.

I believe that this is even more pronounced where grease is used on eccentrics. We are using grease on the eccentrics of high-speed four-valve engines, and frequently the application of oil seems to increase the temperature to the touch, although it appears to loosen them up and make them run more freely, and apparently conducts the heat away more rapidly. J. C. HAWKINS.

Hyattsville, Md.

Standardization of Transformer Polarity

Both the manufacturer and user are agreed as to the desirability of standardizing the polarity of transformers to simplify installing, ordering and preventing mistakes, such as short-circuits, and abnormal voltages of units operating in parallel or three-phase banking. Notwithstanding that discussion has centered round polarity standardization for several years among engineering and operating societies, standardization is not yet in sight, and as pointed out in *Power* for May 29, even when decided upon it must be many years before all transformers in service will be of standard polarity. This means that for several years to come units of different polarity will come up for discussion in specifications, work orders, etc.

Why not standardize the method or methods of specifying transformer polarity? At present different manufacturers understand different things when describing polarity, hence errors may occur in ordering. Of course, were polarity standardized, the need of having one method of describing polarity or one that would be universally understood would disappear, but as already pointed out in your columns, that time is still far distant.

In discussing transformer polarity either the internal or external polarity may be understood. Internal polarity depends upon the relative direction in which the turns of the windings are wound with respect to one another, and when wound they cannot be changed without rebuilding the unit. The purchaser is not concerned with internal polarity except where special cases of inductance and voltage unbalance are concerned, or at voltages of 60,000 and above, where electrostatic effects may enter due to the capacity between turns, coils and secondary circuits. External polarity, on the other hand, depends entirely upon the manner in which the leads are brought out of the case and may be changed by reversing the leads. Roughly speaking, it is with the external polarity only that the user is concerned. At present there are, to the writer's knowledge, at least three ways of explaining the polarity of a transformer. Some manufacturers use one, some another. Again, operating companies test polarity in different ways, and engineers in the same company cannot state the polarity of the same transformer without diagrams based upon test. Surely it would be far preferable to once and for all decide upon a way of stating the polarity of a transformer so as to eliminate the need for testing or drawing diagrams. Perhaps the best way to explain the different ways of stating the polarity of a transformer is to explain how that polarity is determined.

Where direct current is available, a current of known polarity is passed through the high-voltage winding, while the kick in the low-voltage winding is noted on a voltmeter when the circuit to the high voltage is closed. The voltmeter kick indicates the direction of current flowing in the low-voltage coil, whereas since the direction of the high-voltage coil is known, the respective polarity is easily determined. Unfortunately, different engineers disagree as to what is negative or positive polarity of the primary and secondary windings, hence error may enter unless a diagram is employed.

Where alternating current is used for checking polarity and the secondary voltage is low or a ready means exists for controlling the primary volts, comparison between two units may be made by connecting the corresponding terminals together—the high voltage directly, the low voltage through a fuse or lamps, as at F, Fig. 1. Potential is then applied to the primary E_p, and if polarity of both units is the same, there will be no interchange of current between the two units if the ratio is the same. If the polarity of one is opposite that of the other, double voltage exists, since the two secondaries are in series, and the lamps will light on the fuse blow. However, this method gives no means of stating the polarity.

Another alternating-current test consists of connecting one high-voltage and one low-voltage lead together as at A, Fig. 2, impressing a voltage E_p across the high-voltage winding and measuring the pressure across both windings at E. The polarity is then understood to be positive when the voltage E is equal to the sum of the primary and secondary volts. Conversely, the polarity is said to be negative when the resultant, or total volts E, is the difference of the primary and secondary.

With these tests determined, it remains to make them applicable to all units, so that an engineer testing the one way may tell another engineer testing some other way his results without going into the details of the test. In other words, standardize the manner of expressing transformer polarity.

Since the terms positive and negative are usually understood to apply to direct-current apparatus, would it not be simple and easily understood therefore if the polarity were stated to be such that it was additive or subtractive? The relation between the voltmeter kick where direct current is used and the additive or subtractive effect with alternating current is readily determined by a sketch, whereas the reverse is not true without a sketch, since the terms positive and negative polarity are used indiscriminately by different operating engineers.

Another method that might be used is that of expressing the phase relation. The voltage induced in a secondary winding is of the opposite direction to that impressed. In other words, it is 180 deg. out of phase,

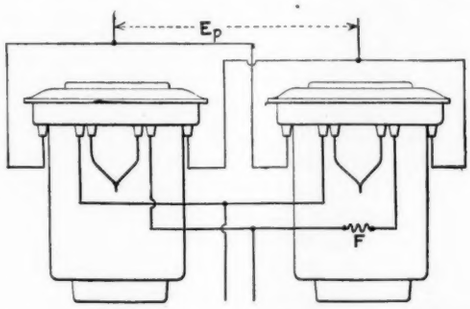


FIG. 1. TESTING TRANSFORMER POLARITY WHEN CONNECTED IN PARALLEL

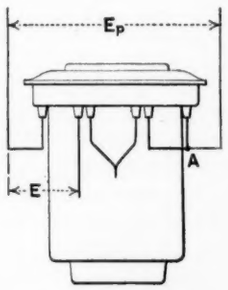


FIG. 2. TRANSFORMER POLARITY TEST

or in opposition. The direction in which this current leaves the case depends upon the leads. Therefore it would be very satisfactory to state the polarity by saying that the phase displacement was zero or 180 deg. out of phase. The relative polarity of the terminals is then immediately determined. With single-phase units the phase relations are either zero or 180 deg., hence no mistake could enter. But with three-phase units or three or even two single-phase units used for three-phase banking, other angles enter; for example, the 30-deg. displacement where one set of coils is in delta and the other in star. Identification by phase angle might then lead to misunderstanding. The A. I. E. E. Standardization Rules discuss transformer polarity upon the basis of marked lead and phase displacement. The marking of instrument transformers has long been in vogue.

Unfortunately, two of the largest manufacturers have, until recently at least, used opposite methods of polarity. How to describe polarity without a sketch or how to state the polarity without stating which leads are identified is the problem. Statements of positive or negative may be made to correspond to additive and subtractive polarity. Then, again, zero phase displacement means subtraction, whereas 180-deg. displacement clearly means opposition or additive result. Yet it is not possible to state the polarity in all three ways and have other engineers understand with an assurance that would permit paralleling two units without the fear of trouble, at present.

Cannot the method or the relation and inter-relation of the different methods of stating polarity be standardized in a way that is simple and reliable and that will not permit of mistakes? Transformers of different polarity must find usage for many years to come, yet if this matter could be settled much annoyance and loss of time might be prevented. LEONARD KENNEDY.

Chicago, Ill.

Comparative Boiler Cost with or Without Economizers

A boiler of 10,000 sq.ft. heating surface will, under normal rating, deliver 30,000 lb. of steam per hour, but how much more can it be made to do and what are the commercial limits?

Broadly speaking, there are three limiting factors: The releasing area in the steam drum limits the quantity of steam that can be taken off without entraining water, causing wet steam; grate area and furnace volume limit the amount of fuel that it is possible to burn without undue operating difficulties and cost of upkeep; decreased efficiency as the steaming rate is increased.

The first objection may be overcome with larger or more steam drums. A boiler can readily be designed to release 9 lb. of steam per hour per sq.ft. of heating surface, when good boiler-feed water is used. This has been done, with no trouble from priming or wet steam.

The second objection can be overcome as follows. Consider a three-pass horizontal water-tube boiler arranged 14 tubes high operating with a steam pressure of 200 lb. and producing 6 lb. of steam per sq.ft. of heating surface when burning Pittsburgh bituminous coal. The chimney-gas temperature will be about 550 deg. F. and the over-all efficiency about 70 per cent. This is commonly termed 200 per cent. rating and is demonstrated to be perfectly feasible and excellent practice, but when this 200 per cent. is greatly exceeded, the furnace volume is too small and the furnace brickwork deteriorates rapidly and the grate area is too small to burn the increased amount of coal. The grates become overloaded, ashes and clinkers cannot be readily disposed of, the combustion efficiency drops seriously, and the operation is impractical.

If, however, this 10,000 sq.ft. boiler instead of being 14 pipes high is made 10 pipes high, it is evident that the width of the boiler and furnace is increased by approximately 40 per cent. As sufficient coal may be burned under the 14-high boiler to develop 200 per cent. of rating, it is evident that with the 10-high boiler 40 per cent. more coal can be burned with the same ease and 280 per cent. of rating developed, but at the expense of boiler efficiency if the gases of combustion are discharged at a higher temperature. It becomes necessary then to install apparatus to efficiently reduce the temperature of the exhaust gases in order that the third objection be overcome and the entire problem be solved. Such apparatus is the economizer. It is estimated that a 10-high boiler, operating at 300 per cent. of rating, with steam pressure at 200 lb., fired with Pittsburgh coal of 13,500 B.t.u. per lb. and about 18 lb. of air per pound of coal will discharge the gases of combustion at about 650 deg. F. Under these circumstances the economizer will raise the feed-water temperature one degree for each 2½ degrees reduction of the flue gases. It is perfectly feasible to reduce the flue gases to 400 deg., and in doing this to raise the feed-water temperature 100 deg.

Therefore by the installation of a comparatively low but wide boiler, it is feasible to operate at 300 per cent. of rating if an economizer is installed; and the efficiency will not only equal that of boilers without economizers operating at normal rating, but will actually exceed it because the exhaust gases are discharged at practically steam temperature. There will be a large saving in the investment in boilers. The costs of the stoker and fan equipment, coal- and ash-handling apparatus, etc., are all reduced because of the better efficiency of the steam-generating units. The upkeep of the boilers is reduced at least one-third because only two-thirds of the boiler units normally used are installed. This boiler upkeep more than offsets extra economizer upkeep, and the expense of the installation of economizers is not nearly so great as that saved on boilers.

Modern stations in some instances have adopted this plan, as it is logical from first to last and is bound to gain favor as the cost of fuel increases and steam pressures are increased. Economizers have been in practical operation for years with steam pressures up to 300 lb., which is as high pressure as will be found in industrial plants or in most central stations.

It is necessary, however, with economizers to use induced draft, but the cost of these fans with their drive is less than the stacks that would probably be used if the economizers were eliminated. In other words, there is a net saving in investment.

Pittsburgh, Penn. F. B. ALLEN.

Inquiries of General Interest

Boiler Furnace for Burning Lignite—What form of boiler furnace gives the best results for burning lignite?

M. V. M.

The best results are to be obtained with furnaces of the reverberatory type. The volatile content of the fuel is high, and for good results with any type of furnace employed, a larger combustion space is required than for burning bituminous coal, with the purpose of securing as complete combustion of the gases as possible before they are brought in contact with the heating surfaces of the boiler.

Large End of Bearing Wedge To Be Down—With a wedge form of tightening for connecting-rod bearings, should the large end of the wedge be placed up or down?

L. C.

With the large end of the wedge up the bearing may become tightened by the wedge working down and the tightening of the bearing may cause heating and cutting without previous notice. It, therefore, is preferable to have the large end down so that, on becoming loose, it may fall and slacken the pressure on the bearing, of which due notice will be given by pounding.

Sample Lists of Examination Questions—Are sample lists of questions asked of candidates for engineers' licenses generally issued by the examining boards? H. C.

Questions relating to citizenship, residence and general personal qualifications of candidates are usually obtainable on application to the examining boards, and in some instances the examiners, when requested, will furnish applicants with sample lists of technical questions asked in past examinations to indicate the classes of subjects to be covered and the degree of proficiency expected in a future examination. It is not to be inferred, however, that the identical question thus quoted will be asked in future examinations.

"Vacuum Chamber" on Pump—What is a vacuum chamber for a pump, and how is it used? M. C.

The term "vacuum chamber" is commonly employed to designate an air vessel attached to the suction side of a reciprocating pump to permit a steady flow of the supply. The word "vacuum" used in this connection is a misnomer, as, for performing its proper function, the vessel must contain air to act like a spring cushion the same as air in the ordinary air chamber placed on the discharge side of a pump. The action is the reverse, however, for the air chamber converts an intermittent discharge into a continuous flow, while the "vacuum chamber" converts a continuous flow in the suction pipe into an intermittent supply to the pump.

Determining and Adjusting Piston Clearance—How is the obtainable amount of piston clearance of an engine determined, and how is it adjusted? J. W. B.

Place the engine on either center and make a mark on the crosshead to register with a mark made on the guide. Then place the engine on the center and make another mark on the guide to register with the mark previously made on the crosshead. The distance between the marks made on the guide will represent the length of the stroke. Disconnect the connecting-rod and, with the piston hard against first one end and then the other end of the cylinder, each time make a mark on the guide to correspond with the mark on the crosshead. The distance the crosshead has thus been placed beyond the marks previously made on the crosshead will be the amount of piston clearance the engine has at each end of the stroke. Ordinarily, the piston clearance should be the same at each end, and the greatest amount of piston clearance available would be half of the sum of clearances of both ends. With greater clearance showing on the head end, the clearances can be equalized by shimming out the length of the connecting-rod one-half of the amount that the head-end clearance is greater than that on the crank end. If greater clearance is found to be on the crank end, the connecting-rod should be shortened by one-half the difference by less shimming. When the piston rod is screwed into the crosshead, equalization of the piston clearance can be made by unscrewing the piston rod out of the crosshead for lengthening or screwing it in for shortening, in place of lengthening or shortening the connecting-rod, provided the adjustment would not impair the strength or alignment of the connections.

Finding Dryness of Steam with Throttling Calorimeter—What formula or chart is used for determining the percentage of dryness of wet steam with a throttling calorimeter? R. A.

The formula for the percentage of dryness is

$$q = \frac{H + 0.47\ (t_s - t) - h}{L} \times 100$$

in which

H = Total heat of 1 lb. of dry saturated steam at the pressure which exists in the calorimeter;

t^s = Temperature of the superheated steam in the calorimeter as indicated by the thermometer;

t = Temperature of saturated steam at the pressure which exists in the calorimeter;

h = Heat of the liquid;

L = Latent heat of evaporation of 1 lb. of dry saturated steam at the pressure of steam sampled.

0.47 is assumed as the mean specific heat of superheated steam for approximately atmospheric pressure existing in the calorimeter and usual values obtained for t_s.

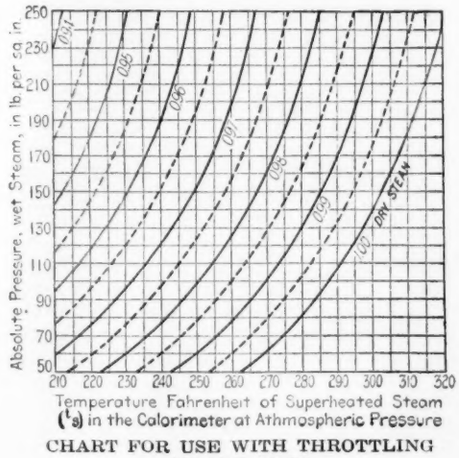


CHART FOR USE WITH THROTTLING CALORIMETER

A convenient form of chart for determining the fraction of dryness with close approximation is herewith reproduced from Pullen's "Engineering Tables and Data."

For finding the fraction of dryness, determine the intersection of the horizontal line through the absolute pressure of the wet steam, and the vertical line through the temperature t_s in the calorimeter, and note the position with respect to the curves of fraction of dryness. Thus, if wet steam at 150 lb. per sq.in. absolute gave a temperature of 240 deg. F. in the calorimeter, the point of intersection coming on the dotted curve between curves 0.96 and 0.97, the fraction of dryness would be 0.965.

Power-Plant Vibrations*

By J. F. PORTER

A number of causes for vibration in power-plant steam and exhaust piping and the remedy for its prevention are presented.

THE mission of the musician is to give pleasure by causing vibrations; engineers are concerned with removing the cause of vibrations. The master musician, to get the desired results, must first acquaint himself with the results of the experiment and study of others; in like manner the experiences and experiments of one engineer may be of value to others.

Mechanical vibration is frequently communicated directly from the engine, and the remedy is to balance the engine, stay the cylinders, reinforce the foundations, or otherwise treat the root of the trouble. In any case the steam pipe cannot be expected to fulfill the functions of a stay to an unsatisfactory engine or foundation, and if a complete remedy cannot be applied, the connecting pipe should possess enough flexibility to avert dangerous stresses on the engine and its connections.

Most high-class engine builders balance their engines so that they will run practically without vibration when attached to a good foundation, but the fact remains that serious trouble has been caused by vibration communicated directly from the engine. Therefore the conditions under which every engine has to be operated should be taken into consideration and every possible precaution taken to prevent any possible vibration communication. This also applies to all reciprocating machinery, such as steam and air pumps, air and ammonia compressors, especially in hotels and office buildings. In one instance the engines were so nicely balanced that a cent could be balanced on edge upon the cylinders or housings, the engines operating at 425 and 490 r.p.m. respectively at full load, yet the vibration was such that some of the tenants of the building threatened to vacate unless it was eliminated.

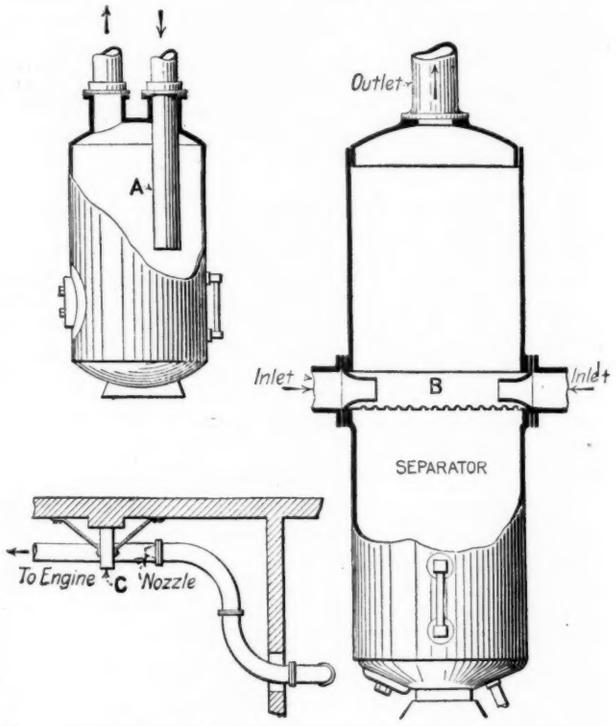
Foundation Not Insulated

The foundation of these engines was built in one concrete block reinforced with steel rods. It was considered a good foundation, but instead of being insulated, it was in contact with three of the main footings supporting the columns which run up through the ten-story building. The owners were advised to remove ten inches from the top of the foundation and replace it with a one-inch cork mat and nine inches of wood, so as to stop the vibration, which it did not do. Although the vibration was lessened to some extent in portions of the building, it increased in the steam-pipe lines so that they had to cease operating the unit.

Before these engines will run without causing vibration through the building, the foundations will have to be insulated with a sand cushion at the bottom as well as at the sides and ends. A space should always be left between foundations and the walls of the engine room, especially where the floor is of concrete, so that any vibration from the machinery will not be transmitted to the walls.

Vibration produced by pulsations of steam is by no means uncommon. An engine may run smoothly, yet the adjacent pipes acquire a rhythmic swing, which is possibly communicated a considerable distance, or even along the entire system. It is not always possible to overcome this effect by additional staying of the pipes, although in many instances a judicious application of chocks and stays may improve matters if care be taken that the expansion arrangements are not neutralized. The vibration is due to the pulsating flow of steam through the pipes, which is a result of the periodic admission and cutting off of the steam at the engine, a surging action constantly taking place. The pulsations, although of small magnitude, are applied with such persistent regularity that if the natural swing period of the pipe coincides with such impulses, the vibration attains a considerable amplitude. In such cases any attempts to anchor the piping would only transmit the vibration farther afield.

Sharp bends and other positions where steam flow is abruptly diverted should, if possible, be avoided. It is at such points that the rapidly recurring impulses of the steam react and thus produce vibration. The amount of steam passing through the main has a direct effect and the greater the quantity the more violent the pulsations and vibration. Therefore if the flow of steam in the pipe is uniformly steady, the vibration will probably disappear. It is desirable that a substantial receiver be provided as close to the engine steam branch as is practicable, with a connecting pipe of liberal dimensions, so as to insure instant response to sudden demands. The adoption of such an arrangement in conjunction with a carefully considered pipe system is an effective safeguard against vibration troubles.



TWO DESIGNS OF SEPARATORS RECOMMENDED AND METHOD OF ANCHORING PIPE LINE

It is desirable that the steam separator adjacent to the engine be about three times the volume of the high-pressure cylinder.

If the steam main is lengthy and has numerous twists with abrupt bends and is freely suspended, a very large receiver is required to compensate for the inherent disadvantages. Probably a capacity of ten to fifteen times the high-pressure cylinder is then necessary as an effectual damper.

A simple and effective type of steam separator is one with the steam entering at the top with an internal pipe *A* extending halfway down, so that an undisturbed rising annulus of considerable area is provided for the up-draft of steam to the outlet branch at the top. The bottom of the separator is in communication with a steam trap, which prevents any accumulation of water.

In addition to steam receivers which, if of sufficient capacity, may partly fail to eliminate vibration, a steadying effect can be obtained by throttling the inlet branch into the receiver with a vena-contracta nozzle, which insures a

*Abstract of paper read before the Engineers' Association, Calgary and Edmonton, Alta., Canada.

more uniform flow and prevents pulsations reaching the steam main. The area of the intake nozzle should be about 36 per cent. of that of the steam pipe; the exact permissible contraction should, however, be determined experimentally.

Another type of separator that has proved very satisfactory in large installations has two steam inlets, one on each side connected into a cross-pipe located about the center of the separator, this pipe being perforated on the bottom side, as at *B*. The inlets are throttled with vena-contracta nozzles, and the steam outlet is at the top of the separator.

In connecting a steam pipe from the main steam header it is often necessary to insert several bends upon which the steam pulsations react and produce vibration. All attempts to secure the pipe forcibly at the seat of the trouble would probably prove futile, as the movement is so complex that one support would be inadequate. Further, it would no doubt be better to allow the pipe to expand than to attempt to oppose it by anchoring. A more satisfactory treatment consists in shutting out the pulsations from the curved section of pipe by inserting a vena-contracta nozzle, the orifice being 25 per cent. of the area of the pipe. This would involve only a slight variation in pressure. The pulsations arising from the engine steam branch would be limited at the throttling point, a fairly even quantity of steam being drawn through the nozzle, although an intermittent discharge is taking place in the direction of the engine.

A tendency toward an end-on movement would possibly still remain, as a result of the impulse kick at the point of contraction. To counteract this a support with diagonal bracing to resist the end thrust is required, as at *C*.

Exhaust-Pipe Vibration

Exhaust-pipe vibration may consist of mechanical vibration in the pipe system, and air vibration emanating from intermittent discharge of steam into the atmosphere.

The latter is a nuisance to surrounding houses, whereas mechanical vibration of pipes is usually local and confined to the station building. Both are, however, caused by steam pulsations due to beats of steam discharged from the cylinder. It is sometimes possible to make a marked improvement by a slight modification of the valve setting. The release point should be arranged so that at full load the pressure in the cylinder gradually drops to the atmospheric line at the end of the stroke. With an early release the cylinder is open to exhaust before the piston has reached the end of each stroke, thus effecting a more gradual discharge into the exhaust pipe. A late release means a more sudden emission of steam from the cylinder. It should be remembered that if the terminal pressure is 25 lb. absolute, about 40 per cent. of the steam is suddenly emitted while the crank is passing the dead-center. It is therefore advantageous to make the release fairly early, and although as a percentage of the stroke this may appear insignificant (when considered as a time function), there is a considerable difference.

Whenever pulsation troubles arise, the indicator cards should be scrutinized, as by resetting for earlier release and later compression the steam flow is prolonged, and this is beneficial in steadying the exhaust and toning down violent concussion at the end of a stroke.

Next consider the pipe itself. Where the engine has an independent exhaust, it is usually of moderate length, and if the bends are made easy, mechanical vibration will not arise. In some instances, where adjacent engines have a combined exhaust, the respective branches are directly cross-connected and a tee provided at the junction. This is a bad arrangement, as the exhausts from each engine collide, and a surging and baffling action continually takes place. It is better to connect the branches into a Y, thus diverting the steam from each engine into the combined pipe, preventing impingement and back pressure incidental to a violent baffling action.

If the steam passage through the exhaust header is restricted, obviously a throbbing action is set up in the pipes leading to this header. The pumping action of the engine exhaust being confined, the condition tends to produce a movement in the pipe system, especially if abrupt bends are numerous. If the pipes are small, violent pulsations occur therein, but as the dimensions of the pipe line are increased the capacity exercises a damping effect and steadies the flow of steam to a great extent.

In such a case exhaust mains should be well supported at suitable points, due regard being given to expansion. Since an intermittent flow of steam into the main is continually present, persistent reactive kicks are applied at every branch inlet, hence reasonable support is desirable at these positions to counteract the tendency to movement, more especially when this is lateral. Roller supports, although good as far as expansion is concerned, do not always steady the pipe system enough.

It is common practice to lead the branches square into the exhaust main, and the pulsating reactive flow sets up transverse vibrations, and the steam is baffled. All bends in exhaust pipes should be made with large radii.

The main is frequently proportioned to be equal only, in carrying capacity, to the branch pipes grouped thereto. It is, however, desirable to make the exhaust main 25 to 30 per cent. larger in diameter throughout its length, this providing a reasonable capacity which exercises a marked steadying effect, damping out the pulsations of the intermittent discharge from the cylinders. The vertical pipe leading to the atmospheric outlet should be reduced to normal dimensions, the larger exhaust main being reduced at its extremity to suit.

To insure a quiet exhaust discharge to the atmosphere, the steam should be in the nature of a steady flow at moderate velocity. It is not, therefore, advantageous to have the vertical pipe too large, as the beat of the engine is more likely to be communicated right up to the discharge outlet, which is just what should be avoided.

The coning down of the exhaust main at the extremity confines the beating action of the steam to the reservoir. It is not uncommon to experience serious difficulty in maintaining a quiet exhaust to the atmosphere.

Government To Train Engineers for the Merchant Marine

The United States Shipping Board is making an effort to ascertain the name and address of every man who can qualify with or without special training for a position as engineer officer on an American merchant ship. They state that within eighteen months 5000 additional engineers in all grades will be needed. To start training those not yet qualified to obtain United States papers, the Government will on July 20 open a chain of free schools at some of the best-known technical colleges in the country, to which marine engineers of all grades, oilers and water tenders and also stationary engineers are eligible for admission for one month's intensive training. After passing the examinations of the steamboat service, the students will have an opportunity for further training under service conditions until they are wanted on the ships of the new merchant marine.

Requests for information regarding training schools should be addressed to Henry Howard, Recruiting Officer, United States Shipping Board, Customs House, Boston, Mass. Applicants must be over 19 years of age, citizens of the United States either by birth or naturalization and must give three reputable references. Preference in selection will naturally be given to those who have had service aboard ship, therefore such service records should be produced. All of the foregoing also applies to navigation officers, captains and mates for the same service.

The executive committee of the Board of Supervisory Inspectors, at a meeting held from June 4 to 12 inclusive, amended the general rules and regulations of the board in regard to experience qualifications for license as masters, mates and engineers of ocean and coastwise vessels. The length of service required for license has been reduced, and some option has been left to the judgment and discretion of local examining inspectors. These amendments have received the approval of the Secretary of Commerce and therefore have the force of law. They were considered necessary on account of the demand for licensed officers and engineers to man the large number of vessels to be added

to the merchant fleet. An applicant for free training is not asked to enlist as in the navy, but if accepted for training in a government school, is expected to sign on for service in the merchant marine. There is no stated period of service, as the pay is so high that men accepted are expected to hold their jobs.

Applicants should plan for their own support while at school (four to six weeks). As soon as a student gets his papers, he will, if selected, go on (junior) pay on a coastwise or South American vessel for two months, when he will be at liberty to go on full pay at the rate prevailing in the transatlantic service.

The schools so far designated are the Massachusetts Institute of Technology, Cambridge, Mass.; Stevens Institute, Hoboken, N. J.; the Case School of Applied Science, Cleveland, Ohio; the Armour Institute of Technology, Chicago; Washington University, Seattle, and Tulane University, New Orleans.

Radiation Error in Measuring the Temperature of Gases*

By Henry Kreisinger† and J. H. Barkley‡

Of the errors entering into the determination of the average temperature of a stream of hot gases surrounded by colder or hotter surfaces, the radiation error is the most serious and the most difficult to correct. Ordinary temperature measurements made with commercial devices under such conditions are from 5 to 25 per cent. in error. If the surrounding surfaces are cooler than the gases, the temperature indicated by the measuring instrument will be too low; if the surrounding temperatures are hotter, as is the case in regenerating furnaces, the temperature indicated will be too high.

The object of the paper by Messrs. Kreisinger and Barkley was to show primarily how large the radiation error may become under certain conditions of temperature measurements and that judgment must be used in determining the accuracy and value of temperature readings.

The radiation error is due to the fact that to a large extent gases are permeable to radiation. When the instrument is inserted in a stream of gases surrounded by surfaces hotter than the gases, it receives heat by radiation from the hot surfaces and at first also by convection from the stream of gases, and its temperature rises. When the temperature of the instrument has risen above the temperature of the gases, the flow of heat from the gases to the instrument reverses, the instrument begins to give off heat by convection to the hot gases and receives heat only by radiation from the surrounding surfaces. The rise of temperature of the instrument continues at a rapidly increasing rate until the quantity of heat received by the instrument by radiation from the hot surfaces is equal to the quantity given off to the stream of gas; the temperature of the instrument then remains constant. With these equilibrium conditions, the temperature of the instrument is somewhere between that of the surrounding surfaces and that of the stream of gases; in other words, it is higher than the temperature of the gases which the instrument is supposed to measure. The difference between the temperature of the gases and that indicated by the instrument is the radiation error.

The magnitude of the error depends mainly on, first, the size of the part of the instrument exposed to the gases and to the radiation and, second, the difference between the temperature of the gases and the temperature of the surrounding surfaces. The smaller the part exposed the smaller the radiation error; also the smaller the difference between the temperature of the gases and the temperature of the surrounding surfaces the less the radiation error. In the measurement of the temperature of gases only the first-named factor can be controlled; the second factor is fixed by the kind of apparatus and its operation.

Of the instruments used in the measurement of the temperature of gases, the thermocouple lends itself the best to the reduction of its size. It can be made so small that the radiation error is negligible. The correct temperature would be indicated only by a thermocouple having an exposed hot junction made of wires of zero diameter, which of course is a physical impossibility.

To determine the effect of the size of the thermocouple, two sets of different sizes were used to measure the temperature of gases in a Babcock & Wilcox boiler fired with natural gas. One of these sets of measurements was taken with thermocouples having the hot junction made of wires 0.008 in. in diameter, and the other set having the hot-junction part made of tubes of about 0.500 in. in diameter. This large couple is about the size of commercial instruments used for such purposes. Several thermocouples of each size were made and clamped together in pairs, each pair containing a large couple and a small couple with the hot junctions about 1½ in. apart. These pairs were placed at different points along the path of gases. All the couples connected to a central switch and read in rapid succession with a portable potentiometer. While the readings were taken, the furnace conditions were kept uniform, which was comparatively easy with the gas firing.

The small couples consistently showed temperatures considerably higher than the large couples, although the small ones themselves read somewhat too low. The difference between the readings of the two couples is nearly proportional to the difference between the true temperature of the gases and the temperature of the surrounding boiler surfaces, which was about 50 deg. higher than the temperature of steam in the boiler. A large couple, placed between the fourth and fifth rows of tubes in the hottest end of the boiler, shows a radiation error of about 575 deg. F., whereas the small couple at the same place indicates an error of only 150 deg. F. In the middle of the tube bank at the uptake end of the boiler where the temperature of the gases is much lower, the large couple reads only about 25 deg. F. too low, and the small couple shows an error of but 5 deg. F.

It is apparent that the radiation error has a definite relation to the size of the part of a couple containing the hot junction. Very likely it is the extent of the surface of the hot junction which determines the magnitude of the radiation error.

Inasmuch as the surface is proportional to the diameter, the radiation error should have a rather definite relation to the diameter of the hot-junction part of the couple.

*Abstract of paper before 1917 spring meeting, American Society of Mechanical Engineers, Cincinnati.

†Engineer, Bureau of Mines. ‡Junior electrical engineer, Bureau of Mines.

Illinois-Iowa N.A.S.E. Convention

The Illinois and Iowa State Associations of the N. A. S. E. held their annual conventions jointly this year at Moline, Davenport and Rock Island, on June 13, 14 and 15. The business meetings of the Illinois Association were held at the Manufacturers Hotel in Moline, and those of the Iowa Association were held at the Blackhawk Hotel in Davenport. The joint meetings and mechanical exhibit were held at the New Harper House in Rock Island.

Particular attention was given to the educational features, six interesting and instructive lectures being provided. At the Wednesday afternoon session C. W. Naylor, of Marshall Field & Co., Chicago, gave a lecture on "Elevators." Frank W. Laas, chief engineer of the Iowa Railway and Light Co., Cedar Rapids, gave an inspiring talk on "The Operating Engineer in Power-Plant Construction." R. H. Holbrook, consulting engineer, of Cedar Rapids, lectured on "The Old and the New in Engineering," and A. T. Baldwin, president of the Precision Instrument Co., Detroit, Mich., gave a talk on "CO_2; What It Is, How To Determine It, and What It Means."

On Thursday afternoon, June 14, H. Murray Jones, of Cedar Rapids, district manager of the Murray Iron Works, gave an illustrated lecture on "Practical Application of the Indicator" and H. S. Budd, district sales manager of the Cameron Steam Pump Co., delivered a paper on "Centrifugal Pumps: Their Classification and Uses."

Wednesday morning and evening were devoted to the inspection of the mechanical exhibit at the New Harper House, where over 30 booths were employed to display various types of power-plant equipment, accessories and supplies.

The entertainment program included an excursion on the Mississippi River through the Moline Locks and over the Le Claire Rapids; on Thursday afternoon a dinner party for the ladies, on Thursday evening a stag party for the men, and on Friday evening a special entertainment and dance.

At the opening exercises of the mechanical exhibit Wednesday evening brief business talks were given by Charles Scott, president of the Illinois State Association; N. W. Bowlby, president of the Iowa State Association; F. W. Long, representing the exhibitors; C. W. Naylor, James D. Beckerleg and Joseph O'Connell, of the Chicago delegation. Entertainment features were provided by W. A. Tilley, of the Lunkenheimer Co., and F. S. Hickey, of the Dearborn Chemical Company.

At the business sessions the Iowa State Association adopted a new constitution and passed the resolution leaving the question of holding a convention next year to the discretion of the state officers.

The following state officers for the Iowa Association were elected: President, F. W. Laas, Cedar Rapids; vice president, Zim Viggers, Des Moines; secretary, A. Davis, Cedar Rapids; treasurer, J. A. Coulson, Sioux City; conductor, Hans Peterson, Marshalltown; State Deputy, R. H. Holbrook. The ceremony of installing the new officers was conducted by National Secretary Raven. Cedar Rapids was selected as the next convention city.

The Illinois State Association elected the following officers: President, John Alt, Ottawa; vice president, J. E. Noden, Moline; secretary and treasurer, Gus Anderson, Chicago. The Illinois Association likewise left the matter of holding a convention next year to the discretion of the state officers. A broader and more comprehensive educational program was provided for with an appropriation of what funds were deemed necessary by, and available to, the educational committee. Ottawa was selected as the next convention city.

American Boiler Manufacturers' Association

The twenty-ninth annual convention of the American Boiler Manufacturers' Association was called to order at 10 o'clock on Monday forenoon, June 25, by President M. H. Broderick, who in his opening address said that instead of discussing the usual questions of plate rivets, etc., the association should devote this meeting to seeing what the boiler makers could do to help the President win the war.

Thomas E. Durban, chairman of the American Uniform Boiler Law Society, reported in detail the work of that society. This report in full will appear in a later issue of *Power*. Toward the adoption of the Code in Massachusetts there had been no progress. The Massachusetts Board of Boiler Rules had asked various states that have adopted the Code to accept Massachusetts boilers, and this request was generally favorably considered, but when the states that adopted the Code asked for reciprocity, it was denied them. Massachusetts was not willing to accord to other states the recognition that she herself was seeking. In one case the favorable action toward Massachusetts had been withdrawn and Massachusetts boilers cannot be shipped into this state.

Mr. Durban also spoke at length on "Boiler Manufacturing During the War," signalized the importance of the boiler and its uninterrupted production at a time when so much depends on the speeding up of the industries dependent on it and recommended a closer and more effective organization of the boiler manufacturers such as will enable them to coöperate more effectively with the Government and to better advantage between themselves when the inevitable break in the present extraordinary conditions comes.

George A. Luck, deputy chief of the Boiler Inspection Department and chairman of the Board of Boiler Rules of Massachusetts, told of steam-boiler regulation in that state. The following sentence from his introduction is significant of the attitude of the Commonwealth on the adoption of the American Society of Mechanical Engineers' Code: "Massachusetts has never been content to follow, but has always aimed to be a pioneer in such matters, and it is universally recognized that even now, when much is being done to build upon her foundation, she is still forging ahead in the matter of improved design, construction, installation, inspection and operation of steam boilers and their appurtenances." He denied that he had asked other states to accept boilers built to the Massachusetts standard and refused to accept those built to the A. S. M. E. Code; and said that Massachusetts had never been formally asked by anybody either to accept the Mechanical Engineers' Code or to modify its own rules to accord with it.

The original boiler inspection law of Massachusetts was passed early in 1895; the Massachusetts Board of Boiler Rules was created in 1907 and has issued ten successive sets of rules, those now in force having been promulgated in May of 1916. Further changes are being considered by the board, one fixing the age of a boiler from the date when it is first put into service instead of that upon which it is built, and another to allow a safety valve with a flat face 40 per cent. more discharging capacity than one with a beveled seat of the same diameter.

Massachusetts passed an air-tank inspection law in 1913 and in 1914 conferred upon the Board of Boiler Rules the supervision of ammonia compressors as to their provision with suitable safety valves.

Since May 1, 1908, there have been constructed under the rules of the department, 16,686 Massachusetts standard boilers and 392 tanks. Manufacturers so desiring have had no difficulty in constructing boilers that meet the requirements of both the Massachusetts Rules and the Boiler Code of the American Society of Mechanical Engineers. The engineer's and fireman's license law was passed in 1895, and under it 143,558 examinations have been made to date.

C. V. Kellogg, vice president of the association, presented an inspiring address on the "Byproducts of the War," predicting beneficial effects on American industrial efficiency and financial supremacy.

Mr. Mason, of the National Tube Co., presented and explained a number of films showing the process of manufacture of seamless steel tubes, and an invitation was extended to the association to visit the works at McKeesport on Wednesday.

A resolution offering to operate the plants of the members during the period of the war in such a way as, in the opinion of the President, would be of most service to the Government and equitable to those involved, was unanimously adopted. Letters were read from Maj. Gen. G. W. Goethals, regretting his inability to be present, but urging the members of the association to speed up their shops for the building of the boilers required by the vessels that he is building.

It was voted to forego the usual banquet and on Monday evening hold an informal round-table dinner, the difference in cost going to the Red Cross. C. V. Kellogg acted as toastmaster, and with many short informal addresses a most enjoyable evening was spent. The Red Cross Corps collected $325.

At the sessions Tuesday, Hon. E. S. Sweet, Assistant Secretary of Commerce, spoke on industrial coöperation in war, causes leading up to the war, how industry can help and the probable conditions after the war. T. J. Duffy, of the Industrial Commission of Ohio, sent his regrets. S. F. Jeter delivered a paper on the "Boiler Inspector and His Relations to the Purchaser and Manufacturer." D. M. Medcalf, chief inspector of Ontario, talked on "Boiler Making in Canada." W. H. S. Bateman reviewed the history of the association and read a paper on the sequel to the indifference of boiler manufacturers toward any improvement that would result in their commercial advancement.

A resolution was passed expressing regret over the death of F. L. Bigelow, and another asking Massachusetts and the United States Board of Supervising Inspectors to revise their rules to conform to the A. S. M. E. Code. The last topic to be considered was a discussion opened by E. R. Fish

on "Standard Flanges for Safety Valves." The place of the next meeting was left to the executive committee, and the present following officers were unanimously reëlected: M. H. Broderick, president; C. V. Kellogg, vice president; H. N. Covell, secretary and treasurer; W. C. Connelly, G. S. Barnum, E. C. Fisher, I. Harter, Jr., and Louis Mohr, executive committee.

Pennsylvania State Convention, N.A.S.E.

The eighteenth annual convention of the Pennsylvania State Association of the National Association of Stationary Engineers was held at Sharon, June 21, 22 and 23, with headquarters at the Shenango House. The meetings of the delegates were held in the main drillroom of the Buhl Armory, a short walking distance from headquarters. The large messroom in the basement of the armory was decorated and arranged for the use of the supplymen for the display of their mechanical wares. The exhibit comprised 28 booths. The local committee met the delegates at the railway station and, headed by a band of music, marched to the convention hall. Tommy Green, of the Garlock Packing Co., was color bearer of the parade.

Many important measures were brought up and discussed by the delegates, the most essential being the necessity for increased efficiency in the engineer and the urgent need of a state license law. The delegates promised to bend their best efforts in this direction, and hoped to report important progress at the next convention. On motion of Samuel B. Forse, national treasurer, the delegates went on record to support the Government in every way toward the successful termination of the war, and that the Governor of Pennsylvania be notified to this effect. Charles Garlick, past national president, was to address the delegates at the Thursday morning session, but was unable to be president on account of ill health. At the Friday afternoon session interesting addresses were made by Col. Daniel Ashworth and S. N. Shook representing National President John A. Kerley. The opening exercises of the convention took place on Thursday morning at the Buhl Armory, with James J. Kelly, chairman of the local committee, occupying the chair. Mr. Kelly was pleased to be one of a committee that brought about so successful a convention, and thanked the Chamber of Commerce for its help and liberality in the preliminary arrangements. Solicitor Fred. Fruit spoke of the pleasure it was to entertain the visitors at Sharon, and hoped their stay would be pleasurable and profitable. Louis S. Evans, state president, responded for the engineers; he told of the advantages of the N. A. S. E., how its members at all times worked for the interest of the employer, and that frequently those efforts were not appreciated by the bosses, but he urged them to persevere. J. T. Dougherty, manager of the Sheet and Tinplate Co., gave a short but impressive talk on the manufacturing industries of Sharon, and advised the convention to visit some of its large plants. Robert W. Larkin, of Chicago, in a brief address told how the *National Engineer* was the foundation and life of the organization. Samuel B. Forse, national treasurer, told of the value of the N. A. S. E. to the engineer. The delegates then went into executive session and State President Evans appointed the various committees, after which an adjournment was taken until 2 p.m.

On Thursday evening there was an informal dance at the Buhl Armory. The march was led by Samuel B. Forse. Ornamental headgear was distributed to the ladies by the Eagle Lubricating Co.

On Friday afternoon the delegates and supplymen visited the Union Brewery, where they were hospitably received and entertained by the manager, Brother Wilson, an old member of the organization.

On Friday the ladies attended the matinee performance at the Thomas Theater.

On Friday evening the exhibitors gave an entertainment at the convention hall. Edith and Leona Symonds sang duets and solos; Bycroft and Acres gave a comedy sketch and Jack Armour, of *Power*, told stories and recited. Mildred Rumbel was the pianist, and Tommy Green acted as master of ceremonies. At the close of the entertainment the menfolk adjourned to the Apollo Maennerchor Club, where a smoker was enjoyed. The speeches were short, the entertainers were good, and refreshments were liberally served at intervals.

On Saturday morning E. W. Alderman, of the Viller Manufacturing Co., and Heine Knoch, both of Pittsburgh, gave an exhibition of fancy and perilous auto driving.

On Saturday afternoon, by courtesy of the Chamber of Commerce, the convention visited the Country Club, where an appetizing luncheon was served.

On Saturday evening there was a fare-thee-well social session at the Apollo Maennerchor Club.

DELEGATES AND GUESTS AT THE PENNSYLVANIA STATE CONVENTION, N. A. S. E., JUNE 21-23

At the closing session of the delegates the following state officers were duly elected and installed: Ernest Uff, president, Chester No. 2; F. B. Mallett, vice president, Sharon No. 6; J. N. Calvert, secretary, Pittsburgh No. 3; Thomas Wilson, treasurer, Lacony No. 8; Charles Keheir, conductor, Lacony No. 8; Michael Malloy, doorkeeper, Philadelphia No. 20.

Chester was chosen for the meeting place in June, 1918.

The boiler of a freight locomotive of the Pittsburgh, Chartiers & Youghiogheny R.R. exploded near Pittsburgh, Mo., on June 21, killing three, the engineer, fireman and brakeman, who were in the cab at the time.

The Bureau of Foreign and Domestic Commerce of the Department of Commerce has just issued a bulletin emphasizing the present need of using our interior waterways. The bulletin is No. 104,354 and is obtainable directly from the Secretary's office. An effort to promote the use of our waterways is a problem of the War Department, the Commission Department and the Shipping Board.

Personals

M. A. Bowlin, for the past ten years connected with the Jacksonville (Fla.) Gas Co., has resigned to take charge of the Macon (Ga.) gas and electric properties.

J. E. Davidson has been elected vice president and general manager of the newly organized Nebraska Power Co., which was formerly known as the Omaha Electric Light and Power Co., at Omaha, Neb.

George M. Brill, who has had a successful engineering practice in Chicago, in the design of power and manufacturing plants, industrial problems, etc., has opened an office at 7 Cromwell Place, White Plains, N. Y.

M. L. Addington, formerly with the Consumers' Power Co., of Jackson, Mich., located at Grand Rapids, Mich., has been appointed manager of the Martinsville Gas and Electric Co., Martinsville, Ind., succeeding W. H. Payne, resigned.

Samuel Insull, president of the Commonwealth Edison Co., of Chicago, received the honorary degree of Doctor of Science at the one hundred and twenty-first commencement exercises of Union College, Schenectady, N. Y., held June 11-13.

Edward J. Kunze, who was professor of mechanical engineering at the Oklahoma Agricultural and Mechanical College, Stillwater, Okla., has resigned to accept a commission as captain in the Quartermaster Officers' Reserve Corps, at Fort Sam Houston, Texas.

New Publications

SYNCHRONOUS MOTORS. Electric Machinery Co., Minneapolis, Minn. Bulletin No. 168; pages 32; 8½ x 11 in.; illustrated.

Describes the construction and operating characteristics of the synchronous motors built by this company. Also useful data are given on the selection of synchronous motors.

EXAMPLES IN BATTERY ENGINEERING. By Prof. F. E. Austin. Published by the author, Hanover, N. H., 1917. Cloth; 5 x 7½ in.; 90 pages; 39 illustrations. Price $1.25.

The author states in his preface that battery engineering is quite distinct from the subject of chemistry or chemical reactions accompanying the operation of batteries. The latter subject is not given extensive consideration in this book, it being deemed expedient to devote the discussion to those features that are of importance in the efficient industrial operation of any and all types or kinds of cells and batteries. The work is divided into twelve lessons, in which are taken up the mechanical and electrical equivalents of heat, classes of primary cells, electromotive force of a cell, current from a cell, cells connected in parallel, series connection of cells, various series-parallel grouping of cells, maximum current from a battery, power obtained from a battery, battery efficiency, types of storage-battery cells, methods of charging including charging from an alternating-current circuit through an electrolytic rectifier, etc. Various problems are worked out showing how to determine the results that will be obtained from different groups of cells and external resistance. The illustrations, for the most part, show different groupings of cells and different connections for charging storage batteries. The little book contains some good practical information and should find a field of usefulness among those who have to do with the operation of primary and secondary batteries.

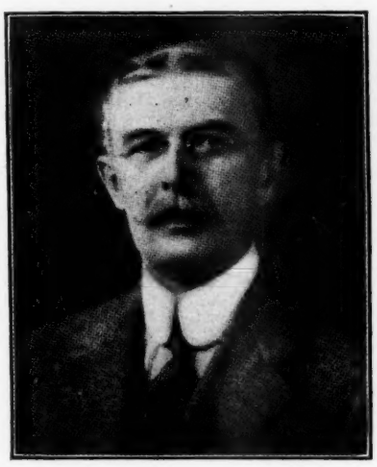
COMPRESSED AIR. By Elmo G. Harris. Published by McGraw-Hill Book Co., Inc., New York, 1917. Cloth; 192 pages; 36 illustrations; 5 charts; 19 tables. Price, $2.

The first edition of this book was presented to the public five years ago. This, the second edition, has been prepared with the view to eliminate all errors and ambiguities and to add matter of value where possible without burdening the text with illustrations and descriptive matter of only temporary value, it being the author's opinion that current practice in the general form of machines and their details can best be studied in trade circulars, of which there are many very creditable productions, illustrating and describing a great variety of machines. The present work is divided into eleven chapters, which embrace formulas for work, measurement of air, friction in air pipes, other air compressors, special applications of compressed air, the airlift pump, receivers and storage of compressed air, fans, centrifugal or turbo air compressors, rotary blowers and examples and exercises. The work is a mathematical treatise throughout, the author making use of the calculus where necessary. No attempt has been made to adapt this book to the use of the self-made mechanic except by the insertion of more complete tables than usually accompany such works. Some 46 formulas are derived throughout the book. These are all indexed in the front of the volume, where they may be readily referred to. A chapter on centrifugal fans and turbine compressors has been added to this edition, which gives a clear concise presentation of the theory underlying such machines.

The tables on compressed air are a very important part of the book, many of them being the original work of the author. Another feature is Appendix B on the design of logarithmic computing charts. Appendix C gives the results of an extensive series of experiments made at the Missouri School of Mines to determine the laws of friction of air in pipes under three inches in diameter. Special effort has been made to give examples of practical matter to illustrate some of the important points in the use of compressed air, and to bring out principles and facts not usually appreciated, making the book as a whole a very complete theoretical compendium on compressed air, which should be well received by the mechanical-engineering profession in general.

Obituary

Frank Lewis Bigelow, president and treasurer of the Bigelow Co., boiler manufacturers and prominent in banking circles in New Haven, Conn., died of heart disease on the golf links of the New Haven Country Club on the afternoon of June 20. Mr. Bigelow was born in New Haven 55 years ago and had not been in the best of health for some time previous to his death. He was the son of Ex-Governor Hobart B. Bigelow and Eleanor Lewis, and a graduate of the Sheffield Scientific School. Upon



FRANK LEWIS BIGELOW

his graduation from the university, he went into the business of the Bigelow Co., of which his father was president and founder. He was also president of the National Pipe Bending Co., director in the New Haven Water Co. and in the Merchants' and National Savings banks, president of the Yale Press Club, and a member of many clubs. He is survived by his widow, two sons and one married daughter.

Engineering Affairs

The National Association of Stationary Engineers announces through its national president that under the association's constitution it is compelled to hold the annual convention, as scheduled, at Evansville, Ind., Sept. 10-15; and officers and members of subordinate associations are urged to use their best efforts to make this convention the most successful ever. A fine program is being arranged, and matters of importance to the organization will be presented.

The American Society of Heating and Ventilating Engineers will hold its semi-annual meeting in Chicago, July 18-20, with headquarters at the Hotel La Salle, and the society is planning one of the most important programs it has ever had at a summer meeting. The first will be a military session, at which addresses will be made by representatives of the Army and Navy Departments, the Department of Agriculture, and the National Guard, and papers bearing on military subjects will be read. This will be followed by a drying session, which will include papers on the preservation if food supplies by drying, with special reference to the national economic problem of the day. The District Heating session will include papers and discussion on central-station heating topics and on economic features of the present industrial problem. At the general session there will be presented papers on interesting research and technical topics in the field of heating and ventilation. The society is now, through the agency of a committee recently appointed, in active coöperation with the Government on questions of ventilating, humidifying and heating of battleships. The society has also been invited to prepare a census of its membership for use in connection with the mobilization of engineers that is now under way by the Government.

Trade Catalogs

Valves and Fittings. Edward Valve and Manufacturing Co., 72 West Adams St., Chicago, Ill. Catalog No. 6. Pp. 92; 6 x 9 in.; illustrated.

Acorn Die and Holders. Greenfield Tap and Die Corp., Greenfield, Mass. Pamphlet. Pp. 20; 6 x 9 in.; illustrated.

Business Items

Second-Hand Equipment, Steam, Electrical, Hydraulic, Gas, MacGovern & Co., Inc., 114 Liberty St., New York. List of equipment on hand. Pp. 58; 3½ x 8½ in.; illustrated.

The Speer Carbon Co., of St. Marys, Penn., is building an immense addition to its present plant, which will involve an expenditure of about $500,000 when completed. It is expected that the entire plant will be in full operation by September.

The Terry Steam Turbine Co., in addition to advising the trade that it would be willing to accept Liberty Bonds in payment for Terry turbines, at a special meeting of the board of directors, held June 15, declared an extra dividend of 1 per cent., which dividend the stockholders voted should be paid to the Red Cross.

Red Cross Dividend—The Westinghouse Electric and Manufacturing Co. has declared its regular quarterly dividend of 1¾ per cent. on both preferred and common stock; and in addition, declared an extra dividend of ¼ of 1 per cent. on both common and preferred stock, amounting to about $375,000, for the benefit of the Red Cross.

The Third National Exposition of Chemical Industries will be held at Grand Central Palace, New York, during the week of Sept. 24. A great section of exhibits showing the industrial opportunities the South presents in its raw materials will be known as the "Southern Opportunity Section." There will also be a "Paper and Pulp Industry Section," at which will be many elaborate exhibits. Other interesting exhibits will be from the rubber and textile industries, from dyestuff companies and from the chemical and allied industry companies.

The Westinghouse Electric and Manufacturing Co., at its annual stockholders' meeting on June 13, voted unanimously in favor of the merger of the Westinghouse Machine Co. with its own, and reëlected the following directors, whose terms expire this year, for four years: J. D. Callery, Paul D. Cravath, Harrison Nesbit and James N. Wallace. The Westinghouse Machine Co. held a stockholders' meeting on the same date, and the proposition to merge with the Westinghouse Electric and Manufacturing Co. was carried by a large majority. The following directors, whose terms expired, were reëlected for one year: James D. Callery, E. M. Herr, H. T. Herr, William McConway, John R. McCune, Joseph W. Marsh, L. A. Osborne, Guy E. Tripp and H. H. Westinghouse.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	June 30, 1917	One Year Ago	June 30, 1917	One Year Ago
Buckwheat	.....	$2.05—3.20	$6.00—6.75	$3.25—3.50
Rice	.....	2.50—2.65	5.20—5.85	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	.....	2.20—2.35	4.90—5.00	2.35—2.60

*No prices quoted.

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	June 30, 1917	One Year Ago	June 30, 1917	One Year Ago
Clearfields	$5.25—6.00	$1.00—1.55	$8.75— 9.50	$4.25—5.00
Cambrias and Somersets	5.50—6.25	1.30—1.75	9.00—10.00	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $6.25—6.50, as compared with $2.75—2.85 a year ago; on cars Boston price is $10.50—11.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	June 30, 1917	One Year Ago	June 30, 1917	One Year Ago
Buckwheat	$4.00—4.15	$2.75	$4.50—4.75	$2.65—2.75
Rice	3.40—4.05	2.25	3.75—4.00	2.20—2.25
Barley	2.90—3.10	1.75	2.75—2.90	1.70—2.00

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$6.75—7.00	$6.75—7.00	$5.25—5.75
South Forks	7.00—7.60	.....	5.50—5.75
Nanty Glo	7.00—7.50	.....	5.50—5.75
Somerset	6.75—7.00	6.75—7.00	5.25—5.50
Quemahoning	7.00—7.25	7.00—7.25	5.50—5.75

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shopped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton r.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	June 30, 1917	One Year Ago	June 30, 1917	One Year Ago
Buckwheat	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	....
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	....

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	June 30, 1917	One Year Ago
Slack	5.00	$1.25
Mine-run	4.75—5.00	1.50—1.75
¾-in.	4.75—5.00	1.70—1.85

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump	$3.00–3.25	$2.75–3.25	$5.00	$3.00	$3.00
Lump	3.50–3.75	3.50–3.75	5.00–5.50	3.25–3.50	3.25–3.75
Egg	3.50–3.75	3.50–3.75	5.00–5.50	3.25–3.50	3.25–3.75
Nut	3.50–3.75	3.50–3.75	.....	3.25–3.50	3.25–3.50
No. 1 nut	3.50–3.75	3.50–3.75	.....	3.25–3.50	3.25–3.75
No. 2 nut	3.50–3.75	3.50–3.75	.....	3.25	3.25
No. 3 nut	3.00–3.50	3.00–3.25	.....	.....	.....
No. 1 washed	3.50–3.75	.....	.....	.....	.....
No. 2 washed	3.50–3.75	.....	.....	.....	.....
Mine-run	3.00–3.25	2.75–3.25	5.00	2.75–3.00	2.75–3.00
Screenings	2.75–3.25	2.75–3.25	.....	2.25–2.50	2.50–3.00

Hocking lump, $4.50—4.75; splint lump, $4.25—4.75.

St. Louis—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	June 30, 1917	One Year Ago	June 30, 1917	One Year Ago	June 30, 1917	One Year Ago
6-in. lump	$3.50	$1.50	$2.35	$1.25	$2.50	$1.00
2-in. lump	3.50	1.40	2.25	1.15	2.15	.85
Steam egg	3.50	1.40	2.25	1.15	2.15	.85
Mine-run	3.00	1.25	2.25	1.10	2.00	.85
No. 1 nut	3.50	1.50	2.25	1.25	2.25	1.00
2-in. screen	2.50	1.00	2.00	.90	1.80	.85
No. 5 washed	2.50	.70	1.70	.75	1.60	.70

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.75	Carbon Hill	$3.25—3.50
Big Seam	3.00—3.25	Cahaba	4.00
Black Creek	4.00		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Idaho, Boise—The Swan Falls plant of the Idaho Power Co. plans to spend $500,000 to improve its plant and to increase the output to 8000 h.p. The company also plans to build an electric transmission line into the Jarbridge district. H. B. Water, Ch. Engr.

Idaho, Eagle—The Idaho Power Co., Empire Bldg., Boise, is having surveys made for the building of a 3-mi. transmission line from Eagle to what is known as the Wise Project, to furnish electricity to irrigate a tract of approximately 700 acres. H. B. Waters, Ch. Engr.

Ind., Bicknell—Knox County Commissioners granted franchise to Indiana Power & Water Co. to furnish electricity in Edwardsport, Westphalia, Freelandville and Sandborn.

Ind., Ligonier—The Indiana & Michigan Electric Co., 220 West Colfax Ave., South Bend, has purchased the local electric light plant and plans to build a 28-mi. transmission line to connect the local system with the lines of the Indiana & Michigan Electric Co. L. H. Andrus, Supt.

Iowa, Iowa City—The Iowa City Light & Power Co. applied for a franchise to build an electric transmission from Iowa City to River Junction to supply electricity there. F. Robinson, Coralville, Engr.

Md., Sparrows Point—The Dundalk Co., recently incorporated with $5,000,000 capital stock, is making arrangements to develop property at Sparrow Point for an industrial city, work includes the installation of an electric-lighting system, which, with other work, will cost about $150,000. E. H. Bouton, Munsey Bldg., Baltimore, Pres.

Mass., Falmouth—The Buzzards Bay Electric Co. filed petitions with the Bd. of Gas & Electric Light Commissioners for permission to build an electric transportation line between its stations in Falmouth and Chatham for the purpose of supplying electricity to the substations at Hyannis, South Yarmouth, North Harwick, Chathamport and Osterville. C. C. Shaw, Falmouth, Engr.

Minn., Morgan—The Wherland Electric Co. plans to extend its service to the villages of Vesta and Seaforth. A. Green, Mgr.

Neb., Ogalalla—City voted bonds for a new steam power plant and for extensions to the distributing system. J. H. Class, Supt.

N. J., Irvington—The Kraeuter & Co., 571-585 18th Ave., Newark, plans to build a new boiler plant to their new tool manufacturing plant being built on Nye Ave. Total cost, $160,000.

N. J., Jersey City—The Delaware, Lackawanna & Western R.R., 90 West St., New York City, plans to build a new boiler plant in connection with the round-house and shops to be built on 16th St. Estimated cost, $50,000. G. J. Ray, Hoboken, Ch. Engr.

N. J., Newark—The Bd. Freeholders has approved $25,000 fund in addition to the recent appropriation of $165,000 to improve and install new equipment for the power plant at the Essex County Hospital at Overbrook.

N. D., Valley City—The Cheyenne Valley Light & Power Co., recently organized, plans to build a high-tension transmission line from Valley City to Dazey, Sanborn, Rodgers, and other places in this section of the state. Energy for operating system will be obtained from the municipal plant at Valley City.

Ohio, Hamilton—The Ohio Gas & Electric Co. of Cincinnati, has been granted permission by Judge Harlan to erect poles in Butler County and cross roads with its wires without obtaining permission of the county officials. This gives the municipal electric plant in this city a competitor for furnishing electricity for lamps and motors. C. W. De Forest, 4th and Plum Sts., Cincinnati, Engr.

Ore., Myrtle Creek—City Council plans to call election to vote on $25,000 bonds to build a municipal electric power plant.

Penn., Philadelphia—Baugh & Son Co., manufacturer of chemicals, oils, etc., plans to build an addition to its engine plant on the Morris St. wharf.

Wash., Tacoma—H. F. Gronen, Comr. of Light and Water, is receiving bids until July 2nd for furnishing 2 lighting feeders, panels and appurtenances for installation at the municipal substation. Bids will also be accepted as a whole or in separate items as follows: Polished marble switchboard, switchboard material, voltage regulators, disconnecting switches, breakers, insulated cables, oil circuits, bus bar copper and fiber copper.

D. C., Wash.—The Quartermaster's Department has finished its estimate of the amount of building material required in each of the cantonments for the national army. The amount of electrical equipment will vary with the shape of the cantonments; the estimate for the total requirements for the 16 military cities amounts to 20,800,000 ft. of insulated wire, 260,000 ft. of lamp cord, 125,000 key sockets and about the same number of shades, 150,000 cleat receptacles, 22,600 snap switches, 27,800 combined switches and plug cut outs, 75,000 plug fuses, mostly for 10 amperes current, 3,000,000 pairs of 2 wire unglazed porcelain cleats and 175,000 pairs of single wire cleats, 1,250,000 porcelain tubes 4 in. long with a ⅝-in. hole, about 7,000,000 1¼ to 2¼-in. wood screws; 9600 lb. of friction tape, 4800 lb. of solder and other items on a similar scale.

Wis., Milwaukee—The Chicago & Northwestern R.R., Jackson Blvd., is building a roundhouse at its Chase Yards, near the south city limits. The work involves coal chutes, under pits and power plant. Estimated cost, $350,000. S. G. Strickland, Chicago, Gen. Mgr.

Wis., Milwaukee—St. Joseph's Convent, 22nd and Greenfield Aves., plans to build a power house.

Wis., Shawano—City clerk receiving bids until July 2 for an electric generating unit for the municipal electric-light plant as follows: 1 simple, high-pressure, non-condensing, heavy duty Corliss engine suitable for direct connection to a 250-kw., 2300-volt, three-phase, 60-cycle, revolving field, engine type generator, speed not exceeding 120 r.p.m.; exciter to be of the 125-volt, belted on engine flywheel arms; switchboard to control generator, exciter and voltage regulator; 3 motor-driven pumps. Separate bids will be considered on generating unit. B. Roper is Pres.

Prices—Materials and Supplies

These are jobbers' prices to the power plant

ELECTRICAL SUPPLIES

KNIFE SWITCHES—Following are net prices each in cities named for knife switches mounted on slate base, front connected, punched clip type, 250 volts:

	30 Amp. New York	30 Amp. Chicago	30 Amp. St. Louis	30 Amp. Dallas	60 Amp. New York	60 Amp. Chicago	60 Amp. St. Louis	60 Amp. Dallas
D. P. S. T., fuseless	$0.49	$0.49	$0.49	$0.68	$0.88	$0.89	$0.88	$1.22
D. P. S. T., fused..	.76	.76	.76	1.06	1.30	1.30	1.30	1.80
D. P. D. T., fuseless	.84	.84	.84	1.16	1.44	1.44	1.44	2.00
D. P. D. T., fused..	1.58	1.58	1.58	2.20	2.45	2.45	2.45	3.40
T. P. S. T., fuseless	1.15	.73	1.15	1.02	1.32	1.32	1.32	1.84
T. P. S. T., fused..	1.15	1.15	1.15	1.60	1.94	1.94	1.94	2.70
T. P. D. T., fuseless	1.92	1.30	1.92	1.80	2.23	2.23	2.23	3.10
T. P. D. T., fused..	2.53	2.53	2.53	3.52	3.92	3.92	3.92	5.44

	100 Amp. New York	100 Amp. Chicago	100 Amp. St. Louis	100 Amp. Dallas	200 Amp. New York	200 Amp. Chicago	200 Amp. St. Louis	200 Amp. Dallas
D. P. S. T., fuseless	$1.80	$1.80	$1.80	$2.50	$3.24	$3.24	$3.24	$4.50
D. P. S. T., fused..	2.64	2.64	2.64	3.66	4.87	4.87	4.87	6.76
R. P. D. T., fuseless	3.24	3.24	3.24	4.50	5.40	5.40	5.40	7.50
D. P. D. T., fused..	5.33	5.33	5.33	7.40	9.36	9.36	9.36	11.70
T. P. S. T., fuseless	2.71	2.71	2.71	3.76	4.87	4.87	4.87	6.76
T. P. S. T., fused..	3.96	3.96	3.96	5.50	7.30	7.30	7.30	9.13
T. P. D. T., fuseless	4.97	4.97	4.97	6.90	8.35	8.35	8.35	10.44
T. P. D. T., fused..	8.52	8.53	8.52	10.66	14.98	14.98	14.98	18.72

Lots $25 and more, list.

FUSES—Following are net prices of 250-volt inclosed fuses each, in standard packages, in cities named:

	New York	Chicago	St. Louis	Dallas	Package
30	$0.09	$0.13	$0.09	$0.13	100
31-60	.14	.18	.12	.18	100
61-100	.34	.46	.32	.46	50
110-200	.72	1.02	.70	1.02	25
225-400	1.24	1.83	1.26	1.84	25

FUSE PLUGS, PER 100

	New York	Chicago	St. Louis
30	$3.50	$4.50	$3.90

Standard package fuse plugs, 500; 100, less than package, 5c. each.

SOCKETS—Following are net prices in cents each in standard packages in cities named:

	⅛-In. Cap Pkge.	Key	Keyless	Pull Chain	¾-In. Cap Pkge.	Key	Keyless	Pull Chain
New York	500	20.00	18.00	36.00	250	20.00	19.00	38.00
Chicago	500	23.10	21.00	42.00	250	27.30	25.20	46.20
Dallas	500	23.76	21.60	43.20	250	28.08	25.92	47.52
St. Louis	500	21.78	19.80	39.60	250	25.74	23.76	43.56

	Pendant Cap Package	Key	⅛ In. Keyless	Pull Chain	Less Than ⅛ More Than Key	Package in Pendant and Keyless	and 25 Each Pull Chain
New York	250	20.00	18.00	42.00	21.00	21.00	48.00
Chicago	250	23.10	21.00	42.00	28.05	25.50	51.00
St. Louis	250	21.78	19.80	39.60	26.40	24.00	48.00
Dallas	250	23.76	25.50	43.20	28.05	25.50	51.00

CUT OUTS—Following are net prices each in cities named for standard package quantities:

EDISON PLUG 0-30

	Package	New York	Package	Chicago	St. Louis
D. P. M. L	50	$0.16	150	$0.17	$0.17
T. P. M. L.	50	.23	100	.24	.24
D. P. S. B.	50	.18	100	.18	.18
T. P. S. B.	50	.32	75	.30	.30
D. P. D. B.	25	.37	100	.34	.34
T. P. D. B.	25	.54	50	.50	.50
3- to 2-wire D. B.	25	.34	100	.35	.35

CARTRIDGE FUSE

	0-30 New York	0-30 Chicago	0-30 St. Louis	31-60 New York	31-60 Chicago	31-60 St. Louis	61-100 New York	61-100 Chicago	61-100 St. Louis
D. P. M. L.	$0.33	$0.30¼	$0.30	$0.84	$0.77	$0.77	$1.68	$1.54	$1.48
T. P. M. L.	.48	.44	.44	1.20	1.10	1.10	2.40	2.20	2.16
D. P. S. B.	.42	.38½	.39	1.05	.96¼	.96	...	...	...
T. P. S. B.	.81	.74¼	.74	1.80	1.65	1.65	...	...	...
D. P. D. B.	.78	.71½	.72	2.10	1.92½	1.93	...	...	...
T. P. D. B.	1.35	1.23¾	1.24	3.60	3.30	3.30	...	...	...
3- to 2-wire D. B. ..	.90	.82½	.83	2.52	2.31	2.31	...	...	...

Note—Prices are based on quantities of 100.

SEPARABLE ATTACHMENT PLUGS—Following are prices each in cities named:

	Package	Porcelain	Composition	Package	Side Outlet Current Taps
New York	250	$0.21	$0.28	50	$0.35
Chicago	250	.198	.264	50	.33
St. Louis	250	.16	.17	50	.33

ELECTRIC FANS—In quantities of 25 to 100, four-blade fans for alternating and direct currents sell in New York as follows:

Inch Diameter	Non-Oscillating 110 Volts	Non-Oscillating Direct Current	Oscillating 110 Volts	Oscillating Direct Current
9	$8.33	$7.62	$13.25	$11.08
12	13.30	12.00	17.00	15.50
16	16.25	14.00	19.75	18.00

CORD—Following are prices each in cities named, in cents per foot:

	Coil, Foot	New York	Chicago	St. Louis
No. 18 cotton, parallel	250	2.83	2.86	2.65
No. 16 cotton, parallel	250	3.65	3.90	3.36
No. 18 cotton, reinforced	250	4.07	4.47	3.05
No. 16 cotton, reinforced	250	4.86	5.51	4.22
No. 18 canvasite	250	3.17	4.18	4.00
No. 16 canvasite	250	3.88	5.28	4.95

	Coil, Foot	New York	Chicago	St. Louis
¼-in. loom	250	2.25	3.00	2.40
⅜-in. loom	250	3.50	4.50	4.05
½-in. loom	200	4.50	6.00	5.40
⅝-in. loom	200	5.75	7.50	6.75
¾-in. loom	150	7.00	9.00	8.10
1 -in. loom	100	10.00	12.50	11.25
1¼-in. loom	100	10.00	16.50	14.85
1½-in. loom	100	15.00	20.00	18.00

COPPER WIRE—Following are prices in cents per foot in cities named for rubber-covered wire in standard quantities of 1000 ft.:

No.	New York Single Braid	New York Double Braid	New York Duplex	Dallas Single Braid	Dallas Double Braid	Dallas Duplex
14..	13.50	14.36	26.00	11.50	14.00	33.00
12..	17.70	19.32	38.04	17.00	18.00	38.20
10..	24.30	26.76	53.04	....	....	....
8..	34.50	37.28	74.16	....	....	....
6..	61.24	64.84	....	....	....	....
5..	72.72	76.72	....	....	....	....
4..	78.96	92.64	....	....	....	....
3..	107.20	112.00	....	....	....	....
2..	131.60	136.80	....	....	....	....
1..	171.20	178.00	....	....	....	....
0..	215.00	215.60	....	224.00	224.00	224.00
00..	264.00	264.00	....	273.60	273.60	273.60
000..	325.20	325.20	....	336.00	336.00	336.00
0000..	396.80	396.80	....	408.80	408.80	408.80

No.	Chicago Single Braid	Chicago Double Braid	Chicago Duplex	St. Louis Single Braid	St. Louis Double Braid	St. Louis Duplex
14..	14.00	16.00	28.00	12.00	15.00	30.00
12..	17.82	20.00	41.90	20.55	21.20	48.40
10..	25.08	27.83	61.49	26.05	29.20	65.50
8..	35.80	39.16	87.50	37.00	40.60	91.60
6..	69.75	69.75	....	66.60	70.65	125.60
5..	82.25	82.25	....	79.00	83.50	148.40
4..	98.25	98.25	....	95.60	100.58	178.80
3..	118.75	118.75	....	103.20	108.60	....
2..	144.90	144.90	....	126.40	131.60	....
1..	188.50	188.50	....	164.40	171.20	....
0..	229.90	229.90	....	207.20	207.20	....
00..	286.00	286.00	....	254.00	254.00	....
000..	344.25	344.25	....	312.00	312.00	....
0000..	422.00	422.00	....	380.40	380.40	....

CONDUITS, ELBOWS AND COUPLINGS—Following are New York warehouse net prices per 1000 ft. for conduit and pet unit for elbows and couplings:

In.	Conduit Enameled	Conduit Galvanized	Elbows Enameled	Elbows Galvanized	Couplings Enameled	Couplings Galvanized
½ ..	$69.70	$74.80	$0.1672	$0.1786	$0.0616	$0.0658
¾ ..	92.00	98.90	.22	.235	.088	.094
1 ..	136.00	146.20	.3256	.3478	.1144	.1222
1¼ ..	184.00	197.80	.4185	.4496	.1581	.1698
1½ ..	220.00	236.50	.558	.5994	.1953	.2098
2 ..	296.00	318.20	1.023	1.10	.2604	.2797
2½ ..	468.00	503.10	1.674	1.80	.372	.3996
3 ..	612.00	657.90	4.464	4.79	.558	.5994
3½ ..	763.60	818.80	9.86	10.59	.744	.7992
4 ..	926.50	991.90	11.39	12.23	.93	.999

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

LOCKNUTS AND BUSHINGS—Following are net prices in New York in standard packages, which are: ½ in., 1000; ¾ to 1¼ in., 100; 1½ to 2 in., 50:

	Locknuts Per 100	Bushings Per 100	Flexible Conduit Box Connections Per 100
½	$1.02	$1.68	$5.62
¾	1.75	4.00	7.12
1	3.00	6.15	10.50
1¼	5.00	8.20	15.00
1½	7.50	10.25	22.50
2	10.00	16.40	30.00
2½	12.30	24.60	67.50

ARMORED CABLES AND BOX CONNECTORS—Following are net prices in New York per 1000 ft. cable and standard package of 100 box connectors in single and double strip:

Wire Gage	Twin Conductor Cable	Twin Conductor Connectors	Three Conductor Cable	Three Conductor Connectors
14	$106.26	$4.50	$75.00	$4.50
12	130.90	4.50	103.95	4.50
10	180.95	4.50	142.45	4.50
8	250.25	5.70	180.95	4.50
6	363.44	8.10	284.90	5.70
4	.....	....	442.75	8.40

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shape Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.30	100	75	$0.65	$0.70	..
15	.27	.30	100	100	1.00	1.05	24
25	.27	.30	100	300	3.00	3.10	24
40	.27	.30	100	500	4.50	4.65	12
50	.27	.30	100	750	6.00	6.25	8
60	.36	.40	100	1000	7.00	7.25	8

Standard package quantities are 10% from above prices. Yearly contracts ranging from $150 up allow a discount of 17% from list.

WIRING SUPPLIES—New York prices for tape and solder are as follows:

Friction tape	25c. per lb.	Wire solder	30c. per lb.
Rubber tape	35c. per lb.	Soldering paste	50c. per lb.

MISCELLANEOUS

HOSE—

Fire

	50-Ft. Lengths
Underwriters' 2½-in.	60c. per ft.
Common, 2½-in.	50%

Air

	First Grade	Second Grade	Third Grade
¾-in., per ft.	$0.55	$0.30	$0.25

Steam—Discounts from list

First grade... 30% Second grade... 30-5% Third grade... 40-10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 50-10% Best grade 25%
Standard 40%

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40%	35%
St. Louis	50%	40%
Chicago	40—5%	35—10%

RAWHIDE LACING—40%.

PACKING—Below are prices each per pound in cities named:

Asbestos

		St. Louis	New York	Chicago
Valve and Stuffing Box	Twisted plain, 25-lb. cartons	$0.80	$0.65@0.70	$1.00
	Twisted graphite, 25-lb. cartons	.90	.90	1.35
	Braided plain, 25-lb. cartons	.80	.80	1.20
	Braided graphite, 25-lb. cartons	.90	1.00	1.55

Asbestos wick in balls, ¼-, ½-, 1-, 25- and 50-lb. cartons, $0.65@0.70, New York; $1, Chicago.

Rubber asbestos, compressed sheets, medium grade about $0.80 in New York, 45c. in St. Louis, $1 Chicago.

Steam

Following in 25- and 50-lb. cartons:

	New York	Chicago	St. Louis
First grade	$0.83	$1.10	$1.45
Second grade	.55	.85	.90

Rubber and Duck

High grade	$0.50	$0.55	$0.60
Cold water	.30	.30	.40

Piston

Asbestos, duck and rubber	$1.75	$2.00	....
Flax, first grade	.94	1.00	$0.90
Rubber and duck	.90	1.00	.70

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard Thickness Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure ..... 15% off

Air cells for low-pressure heating and return lines { 4-ply.... 58% off; 3-ply.... 60% off; 2-ply.... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	New York	Chicago	St. Louis
Cup	5@7	7½	4½
Fiber or sponge	5@7	7¾	5½
Transmission	5@7	6¼	5½
Axle	3@7	5	3½
Gear	4@5	6½	3
Car journal (S. & F.)	6½@7	6	9½

COTTON WASTE—The following prices are in cents per pound:

	New York: May 29, 1917	New York: One Year Ago	Cleveland	Chicago
White	13.00@15.00	12.50	14.00	13.00@15.00
Colored mixed	10.00@12.00	9.00	12.00	10.00@12.00

WIPING CLOTHS—In Cleveland the jobbers' price per 1000 is as follows:

13¼ x 13¼ ..... $35.00 13¼ x 20½ $45.00

In Chicago they sell at $30@33 per 1000.

MANILA ROPE—In New York the price per pound for ⅝-in. and larger in 1200-ft. coils, is 31¼c. Sizes smaller than ⅝-in. from ½c. to 2c. extra per lb. Extra charge of 1c. per lb. for less than 600 ft.

LINSEED OIL—These prices are per gallon:

	New York: May 29, 1917	New York: 1 Year Ago	Cleveland: May 29, 1917	Cleveland: 1 Year Ago	Chicago: May 29, 1917	Chicago: 1 Year Ago
Raw in barrels	$1.31	$0.73	$1.32	$0.75	$1.29	$0.78
5-gal. cans	1.41	.83	1.42	.85	1.34	.83

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red: May 29, 1917		Red: 1 Year Ago		White: May 29, 1917	White: 1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	12.25	12.50	10.50	11.00	12.00	10.50
25- and 50-lb. kegs	12.50	12.75	10.75	11.25	12.25	10.75
12½-lb keg	12.75	13.00	11.00	11.50	12.50	11.00
1- to 5-lb. cans	14.25	14.50	12.50	12.50	13.50	12.50

AMMONIA—Below are prices per lb. in cities named:

	Chicago	St. Louis	New York
26-deg. U.S.P. carboys of 100 lb.	..	....*	7½c.
26-deg. U.S.P. drums of 1000 lb.	6c.	6¼c.	6½c.

Note—Ammonia very scarce.

*Not used here. Anhydrous ammonia in 100-lb. cylinders costs 25c. per lb. in St. Louis and Chicago.

FIRE BRICK—Quotations on the different kinds in the cities named are as follows f.o.b. works:

	New York	Chicago	St. Louis
Silica brick, per 1000	$50.00@55.00	$50.00@75.00	....
Fire clay brick, per 1000, No. 1	45.00@55.00	.....	$40.00
Magnesite brick, per net ton	135.00@145.00	.....	....
Chrome brick, per net ton	135.00	.....	....
Deadburned magnesite brick, per net ton	85.00@90.00	.....	....
Special furnace chrome brick, per net ton	60.00@70.00	60.00@80.00	....

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

FUEL OIL—Price variable, depending upon stock. New York quotations not available owing to this fact. In Chicago and St. Louis the following prices are quoted:

	Chicago	St. Louis
Domestic light, 22-26 Baume	7¾c.	8.5c.

Note—There is practically no fuel oil in Chicago at present time.

POLES—Prices on Western red cedar poles:

	New York	Chicago	St. Louis	Denver
	72-82	52-62	52-62	33-42
6 in. by 30 ft.	$5.59	$4.94	$4.94	$4.32
7 in. by 30 ft.	7.40	6.60	6.60	5.80
7 in. by 35 ft.	10.70	9.60	9.60	8.55
8 in. by 35 ft.	12.20	10.90	10.90	9.65
7 in. by 40 ft.	12.35	11.00	11.00	9.75
8 in. by 40 ft.	13.75	12.15	12.15	10.65
8 in. by 45 ft.	18.20	16.20	16.20	14.30
8 in. by 50 ft.	21.85	19.45	19.45	17.15

Note—These prices are subject to advance on July 1 on account of advanced freight rates.

PIPE—The following discounts are for carload lots f.o.b. Pittsburgh, basing card in effect May 1, 1917:

BUTT WELD

Steel: Inches	Black	Galvanized	Iron: Inches	Black	Galvanized
⅛, ¼ and ⅜	42%	15½%	¾ to 1½	38%	22%
½	46%	31½%			

LAP WELD

2	42%	27½%	1¼	23%	8%
2½ to 6	45%	35½%	1½	30%	16%
			2	31%	17%
			2½ to 4	33%	20%
			4½ to 6	33%	20%

BUTT WELD. EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	38%	20½%	¾ to 1½	38%	23%
½	43%	30½%			
¾ to 1½	47%	34½%			

LAP WELD. EXTRA STRONG PLAIN ENDS

2	40%	28½%	1¼	24%	8%
2½ to 4	43%	31½%	1½	30%	16%
4½ to 6	42%	30½%	2	32%	19%
			2½ to 4	34%	22%
			4½ to 6	33%	21%

Stock discounts in cities named as as follows:

	New York: Black	New York: Galvanized	Cleveland: Black	Cleveland: Galvanized
¾ to 3 in. steel butt welded	44%	28%	43%	28%
3½ to 6 in. steel lap welded	28%	10%	39%	25%

	Chicago: Black	Chicago: Galvanized	St. Louis: Black	St. Louis: Galvanized
¾ to 3 in. steel butt welded	43%	28%	41.27%	26.27%
3½ to 6 in. steel lap welded	39%	25%	37.27%	22.27%

Malleable fittings, Class B and C, from New York stock sell at 5 and 5% from list price. Cast iron, standard sizes, 34 and 5%.

PIPE—The following discounts are for carload lots f.o.b. warehouse, St. Louis:

BUTT WELD

Inches	Black	Galvanized
⅛, ¼ and ⅜	34.27%	6.27%
½	38.27%	22.27%
¾ to 3	41.27%	26.27%
3½ to 6	37.27%	22.27%
7 to 12	34.27%	19.27%

BOILER TUBES—Discounts on less than carloads from Pittsburgh, freight to be added, effective from Nov. 1, 1916, on standard charcoal iron tubes, and from Apr. 2, 1917, on lap-welded steel tubes, are as follows:

Lap Welded Steel		Standard Charcoal Iron	
1¾ and 2 in.	31%	1½ in.	23%
2¼ in.	28%	1¾ and 2 in.	35%
2½ and 2¾ in.	34%	2¼ in.	32%
3 and 3¼ in.	34%	2½ and 2¾ in.	38%
3½ to 4½ in.	34%	3 and 3¼ in.	43%
5 and 6 in.	33%	3½ to 4½ in.	....
7 to 13 in.	30%	5 and 6 in.	37%
		7 to 13 in.	34%

Locomotive and steamship special charcoal grades bring higher prices; 1¾ in., over 18 ft. and not exceeding 22 ft., 10% net extra; 2 in. and larger, over 22 ft., 10% net extra.